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Trans. 511
(Conclusions
only)
By:
R. Adelman

Semenenko, G. I.

Izmenenie Soderzhaniia Nukleoproteidov
v Rasteniiakh pri vegetativnoi Gibridizatsii

[Change in nucleoprotein content in plants
upon vegetative hybridization].

Biokhimiia, 17(6):655-659. November-December,
1952. 385 B523

(In Russian)

CHANGE IN NUCLEOPROTEIN CONTENT IN PLANTS UPON VEGETATIVE HYBRIDIZATION

[Experiments were conducted with tomatoes of the "Marglob" variety; eggplant of the "Delikates" variety; and the seed offspring obtained from tomato/eggplant grafts].

CONCLUSION

In vegetative hybridization, substantial quantitative changes occur in the phosphorus content of nucleoproteins in the young growing organs and tissues of grafts and hybrid progeny.

In grafting tomatoes onto eggplants and vice versa, the change in the phosphorus content in nucleoproteins in the leaves of the scion is inclined to favor the stock, and in the case of repeated grafting it increases.

In the seed progeny of vegetative hybrids, concurrently with a vigorous manifestation of heterosis, an increased nucleoprotein content is observed in the leaves, blossoms, tips of shoots and in the young seedlings of hybrid plants as compared with the original [plant] forms.

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By:
R. Adelman

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Glushchenko, I. E.

Gibridizatsiia Rastenii putem Privivki

[Hybridization of Plants by Grafting]

Uspekhi Sovremennoi Biologii 30(1):15-48
July/August 1950. 442.8 Er3

(In Russian)

HYBRIDIZATION OF PLANTS BY GRAFTING

General Conclusions

1. Vegetative hybrids show that simple heredity characteristic in vegetative reproduction can, as Timiriazev asserted, turn into complex heredity characteristic in sexual reproduction.

2. Experiments in vegetative hybridization show an inconsistency in the chromosome theory of heredity the principle of which is cell from cell, nucleus from nucleus, chromosome from chromosome, gene from gene.

Vegetative hybrids convince one that somatic cells undergoing physiological changes will, in the end, produce altered sexual cells. There is no immortal embryonic course. There is a course of qualitative transformation of soma capable of forming sexual cells at a certain stage.

3. There is a similarity, a parallelism, between sexual and vegetative hybridization. It is a fact that the second method, as well as the first, will transmit any characteristic, any property from one component to the other. These properties become fixed in the seed generations.

4. Side by side with parallelism there exist differences. A typical feature of vegetative hybrids is the different type of fission of characteristics. Not only the plants vary in their basic characteristics, but a sharply pronounced differentiation occurs [proxodit] within the organism. In vegetative hybrids the mixed type of heredity is basically intrinsic.

5. A characteristic of graft hybrids is the different form of manifestation of property dominance. Plants with recessive characterics often produce offspring with dominant characteristics.

6. Crossbreeding carried out between vegetative hybrids and parents with graft components and recessive characteristics demonstrate graphically that dominant characteristics may appear in the offspring. This indicates that separate characteristics in hybrids are in a latent state and, under appropriate conditions, develop subsequently in the offspring.

7. On the change in external morphological characteristics, a profound reorganization of order takes place in hybrids, the character of cell structure changes in particular, plastids of various types appear in the cells.

8. Biochemical investigations show that the majority of quantitative and qualitative indicators of the second graft component — the mentor — appear in the seed progeny.

9. Frequently the absence of visible changes observed in the year of grafting does not denote an absence of specific qualitative changes in the generative cells of the plant. Hence it follows that the progeny of grafted plants must always be investigated, even though no phenomenon of variation in characteristics had been observed in the year of grafting.

10. It would be most primitive to think that as a result of grafting one always has to look for grafts of the stock in the offspring of the scion, or vica versa, to discover properties, characteristics of the scion in the offspring of fruit of the stock. Living [substance] constitutes a process of development, and every biological process does not know of straight, direct changes. They are realized only in a long chain of transformations.

Besides the phenomena of straight hybridism (presence of the characteristics of both parent components in the offspring), vegetative hybrids include also the phenomena of new formations, i.e. the creation of new characteristics frequently not inherent in either one of the graft components. A pre-requisite for this is extreme instability, inconstancy of form, frequently observed in intraspecific and, most often, in distant, [intergeneric] graftings.

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Nikitenko, G. F.

O nekotorykh osobennostiakh vegetativnoi gibridizatsii zlakov metodom transplantatsii zarodysha

[Certain characteristics of vegetative hybridization of cereals by the embryo transplantation method].

Doklady Akademii Nauk SSSR, 76(2):273-276
January 11, 1951   511 P444A

CERTAIN CHARACTERISTICS OF VEGETATIVE HYBRIDIZATION OF CEREALS BY THE EMBRYO TRANSPLANTATION METHOD

Submitted by Academician N. A. Maksimov, November 11, 1950

Research of recent years has developed technical methods making it practicable for a large group of herbaceous plants (principally the Cucurbitaceae and Solanaceae) to bring about exertion of a larger measure of influence by the stock upon the scion, which, as is known, is one of the decisive conditions in obtaining vegetative hybrids (8). The essence of these methods is the influence brought to bear on the scion at various stages of its development, and the regulation of its assimilating (foliar) surface (1,3,8,14).

However, the method for obtaining vegetative hybrids among cereals cannot yet be considered as sufficiently developed. With regard to Gramineae, the more widespread and generally accepted method at present is vegetative hybridization by means of embryo transplantation, although other processes are also known: inarching [ablaktirovka] (3,9), grafting onto the node above ground (6,12). [p. 273, end para 2]

Apart from the greater technical accessibility, the embryo transplantation method permits influencing the scion (embryo) at the very beginning of its development. There are several known alternatives of this method (4,5,7,12,15,16), but all are characterized by a common shortcoming, namely, the altering action of the stock (endosperm) upon the scion (embryo). The latter, being selective as to the conditions of its life, will "reluctantly" make use of the alien plastic substances of the stock — endosperm — and will assimilate them in building up its body only until it forms rootlets and a regular leaf, i.e. until it becomes self-sustaining. With the formation of embryonic rootlets and the bringing forth a leaf above ground, the influence exerted by the endosperm on the embryo, via plastic substances, stops. Frequently this occurs before the supply of the endosperm is all used up, and thus, the influence of the stock (endosperm) upon the scion (embryo) appears to be limited not only with respect to duration of the action, but also as to the amount of the assimilated plastic substances.

Attempts to overcome the indicated shortcomings by increasing the amount of the altering plastic substances in grafting — by doubling the endosperm stock) (15,16) — were not successful. In our opinion, the reason for this lies in the fact that such a treatment of the question solves only the problem of increasing the amount of plastic substances of the stock, but does not touch upon the other, the more important problem — forcing the scion to assimilate food inappropriate for it, and in large quantities at that. On grafting, the plants show essential individual distinctions, and their reaction to the influence of alien food substances is very strong. Consequently, a simple increase in the amount of plastic substances of the stock is not sufficient to obtain the needed changes in grafting by trans- [begin p. 274] planting the embryo — it is important that the latter be compelled to assimilate them. In underestimating this requirement, we are inclined to explain the failures which have occurred in the work of many investigators who are engaged in vegetative hybridization of Graminea and use the method under consideration. (Let us point out, particularly, the experiments conducted by Shtingl [or Stingl] with Triticum, Hordeum, Secale, Avena, cited by Winkler (2), in an attempt to prove that the influence of varying plastic substances is incapable of causing specific changes in grafting).

In the course of experimental work of vegetative hybridization of barley by the embryo transplantation method, we succeeded in detecting conditions allowing, to a considerable degree, to overcome the fundamental fault of this method. The method of vegetative hybridization of cereals which we suggested, frequently led to a very profound influence exerted by the stock upon the scion: we refer to a case of complete suppression of the scion in grafting and the formation of a plant with the characteristics of only the stock (10).

The further development of the problem under consideration was continued under conditions of a specially conducted experiment with biologically contrasting graft component. The varieties of winter barley selected as such components were — [p. 274, para 2] Kruglik 21 and Krasnyi Dar 2494 (Hordeum vulgare L var. pallidum) and two varieties of winter rye — Kazanskaia 5 + 6 and Dotnuvo Aukshtein (Secale cereale L. var. vulgare). The graft was accomplished by use of the method described earlier (10,11). A total of 250 grafts were carried out $\frac{\text{Kruglik 21}}{\text{2 Dotnuvo Aukshtein}}$ and $\frac{\text{Krasnyi Dar 2494}}{\text{2 Kazanskaia 5 + 6}}$ which, on September 1, 1949, were sown in hothouse pots [vazony] containing seed bed earth (50% soil and 50% humus) at a depth of 8-9 cm. Shoots appeared on September 12-14, 1949, i.e. on the 12-14th day following the sowing. Of the 250 grafted grains only 86 germinated; the rest of the 164 produced no shoots.

During the phase of 2-3 regular leaflets, the experimental plants were transplanted to open ground where they were well able to develop runners [raskustit'sia] by the time autumn vegetation ceased.

Even the first observations of the post-grafting development of the experimental plants revealed a profound influence of the stock in the graftings. In 26 out of 86 cases, the shoots which emerged proved to contain anthocyanin, which is characteristic of the stock (of winter rye). As the grafts were developing further, a progressive increase was observed in stock characteristics: conservation of anthocyan at the base of the [p. 274, end para 3] plants, a slightly raised and expanded form of the branch [kust] (the scion of winter barley has a recumbent branch), noticeably less crescent form to the ears of the leaf sheath.

In the spring of 1950, following the overwintering, there were only 12 plants left in the nursery, and these were of the 26 which, in the fall of 1949 had revealed a strong trend in the direction of the stock. The rest of the grafts, exactly as the controls (Intravarietal grafts and ungrafted plants of winter barley), perished completely as a result of the very severe overwintering conditions of 1949-1950. The following spring, the development of the surviving plants was distinguished by considerable originality. In these plants the formation of new leaves and runners were accompanied by the dying off of the old ones, while the newly emerging runners tended ever more toward the stock in an externally morphological sense. It created the impression that the plants, so to say, were discarding their hybrid "jacket". In separate plants the dying off of the vegetative mass proceeded more intensively than the process of forming new ones, so that of the 12 overwintered plants only 3 survived until the time of fruitage. The other 9 died off at different stages: 5 soon after spring vegetation had begun (May 3-8), 3 — in the phase of stem formation [vykhod v trubku] (May 25-29) and one plant at the peak of spike [end p. 274] formation (June 24). At this time it is important to note that, as per our observations, the dying off of grafts was not due to a deficiency of food elements, of light, moisture etc., nor to injuries caused by insect pests, and much less to mechanical injuries, but apparently, to a lack of balance of strain requirements of the graft components.

After spike formation, the development of the plants which survived proceeded normally. At this moment they resembled completely the plants of winter rye; their flowering was rather protracted (June 28 - July 13) and it proceeded in the "rye" manner, i.e. it was open. For the purpose of increasing the percentage of the binding capacity of grain, these plants were artificially backcrossed [pereopyleny] among themselves. In addition, one spike on each plant was isolated (with the aid of parchment isolators) under which no grain whatever formed.

Three plants produced a total of 29 spikes yielding a harvest of 867 grains with an absolute weight of 30.8 g. Viewed from the external appearance, the spikes obtained and the grains in them were clearly of the rye type.

Thus, in our experiment, [p. 275, begin para 3] plants with externally morphological and biological characteristics typical of the endosperm-stock, — winter rye — developed from embryos of winter barley transplanted onto double endosperms of winter rye, if the grafted grains were planted extra deep (8-9cm) and grown under field overwintering conditions. We explain this, undoubtedly, most interesting case of strong influence exerted by the stock upon the scion as follows. Thanks to considerable (with respect to duration and amount of plastic substances assimilated) influence of the endosperm-stock, there occurred in the early stages of graft development a sharp shift in the direction of winter rye. However, the degree to which this shift was expressed in the grafts varied by virtue of the individual differences in the components. The subsequent development of the grafts took place under severe overwintering conditions and caused in some of them a further increase in the characteristics of winter rye, in as much as the prevalence of such conditions evidently contributed to the development, in the grafts, of properties and characteristics of the more hardy component, in the given case winter rye. The other grafts which leaned in the direction of the scion (of winter barley) and, therefore, were less hardy, perished the same as the controls (winter barley) because they could not survive the low winter temperatures. As a result of this, a complete predominance of stock properties [p. 275, end para 3] set in in the grafts which had survived the winter: at the time of full fruitage there were left only the grafts of the extreme variant — "toward the stock"; grafts "toward the scion" and intermediate ones were eliminated.

The data obtained may serve as strong evidence of the feasibility of transmitting the properties of one strain to another without the participation of sex elements, solely by transmission of plastic substances (8). It seems to us, however, that this does not exhaust the importance of the facts disclosed. On the basis of these facts one can assert that to ensure the success of vegetative hybridization of cereals by the process of embryo transplantation, it is not necessary to create conditions that "will maximally accelerate the germination of the scion embryo" (15) by covering the grafts with a thin layer (1 cm) of friable soil, but on the contrary, to pursue the course of prolonging the period in which the changing action of the "strange" food of the endosperm-stock can be exerted. Only in this case one can expect to obtain a high percentage of success in vegetative hybridization of cereals by the method indicated — not in the sense of generally obtaining a large number of plants from grafts, but of obtaining a high percentage of real vegetative hybrids, i.e. plants with the properties of the scion and the stock. [p. 275, end para 4].

It may be assumed that by regulating the depth at which grafted grains are planted [zadelka] (taking into account the size of the seed grafted) and, by the same virtues, regulating the size and duration of the stock influence, combined with expedient cultural practices for grafts, it is possible to obtain stock influence of the needed strength.

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Selektsionnaia Stantsiia

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REFERENCES CITED

(1) A. A. Avakian, Iarovizatsiia, no. 1, (1941)

(2) H. Winkler, Untersuchungen ueber Propfbastarde, Jena, 1912

(3) I. E. Glushchenko, Vĕgetativanaia gibridizatsiia rastenii, M., 1948

(4) L. A. Golovtsev, Agrobiologiia, no. 1, (1948).

(5) V. I. Didus', Selektsiia i Semenovodstvo, no. 4 (1950)

(6) V. F. Illarionov, ibid, No. 11 (1948)

(7) F. M. Kuperman, Iarovizatsiia, nos. 5-6 (1939)

(8) T. D. Lysenko, Agrobiologiia, 1949

(9) G. Kh. Molotkovskii, DAN, 24, no. 4 (1950)

(10) G. F. Nikitenko, Selektsiia i Semenovodstvo, no. 11, (1949)

(11) G. F. Nikitenlo, ibid, no. 5, (1950)

(12) I. G. Plotnikov, Iarovizatsiia, no. 3 (1939)

(13) P. F. Sekum, Selektsiia i Semenovodstvo, no. 2 (1949)

(14) N. V. Turbin, Bot. Zhurn., 36, no. 6, (1949)

(15) V. I. Khmelev, DAN, 70, no. 5, (1950)

(16) V. I. Khmelev, Selektsiia i Semenovodstvo, no. 3, (1950)

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Rautěnshtein, Iā. I.
Cand. Biol. Sci.

[On Utilizing Antibiotics in the
Food Industry]

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vol. 24, no. 5, May 1954, pp. 44-48.
511 Ak14V

(In Russian)

USSR WORK ON THE APPLICATION OF ANTIBIOTICS IN THE FOOD INDUSTRY

[Numbers in parentheses refer to appended bibliography]

The idea of using the antagonistic effects between microbes for combating pathogenic microorganisms had been originally suggested by I. I. Mechnikov. However, practical application of the phenomenon of antagonism between microbes was first attempted in the 1940's, when antibiotics (tyrothricin, penicillin, and gramicidin) were isolated in a pure state.

Modern medicine and veterinary medicine have found in antibiotics a powerful means of combating infectious diseases. It is understandable that the question was raised in regard to the use of antibiotics for the control of harmful microorganisms in some industrial fields as well, particularly in the food industry for the preservation of food products from spoilage (1).

Many investigators, particularly abroad, attempted to apply for this purpose antibiotics which are known and have received extensive application in medicine, namely penicillin, streptomycin, chloromycetin, aureomycin, terramycin, subtilin, gramicidin, etc. The investigations that have been carried out dealt mainly with the problem as to whether the antibiotics mentioned are suitable for the preservation of meat, fish, and milk from spoilage. Notwithstanding certain contradictions which are encountered in published articles, it may be considered as an established fact that small quantities of antibiotics, after being added to the food product or to the ice in which the food product is kept, prevent spoilage for a certain time.

However, none of the antibiotics used in medicine have found practical application in the food industry. The principal reason for this is the natural apprehension that as a result of prolonged consumption of antibiotics microbial forms which are resistant to antibiotics will arise. Experience shows that persons who had been treated with antibiotics develop resistant forms of bacteria in their bodies with relative ease. It is obvious that after the development in the organism of microbes which are resistant to a definite antibiotic, treatment with this antibiotic of the disease produced by the microorganism in question will not succeed. In other words, the application of an antibiotic in the food industry may lead to the result that an effective therapeutic agent will be lost.

On the other hand, there still is no information worth mentioning on the nature of the effect which small doses of antibiotics administered for a long time exert on the human organism.

The rather extensive data pertaining to the action of antibiotics on animals are very contradictory. It was established that addition to the feed of minute quantities of penicillin, streptomycine, chloromycetin, aureomycin, or other antibiotics in some cases, but not always, has a beneficial effect on animals, particularly young animals. It was established that the identical anitbiotics exert a different reaction on different animals. The best results were achieved with aureomycin, terramycin, and bacitracin. The mechanism of this prolonged action of antibiotics has not been investigated adequately as yet. But a number of authors assume, not without reason, that improvement in the growth of young animals, which has been noticed after the administration of an antibiotic in the feed, is produced principally by profound changes in the composition of the intestinal microflora and that these changes are brought about by the action of the antibiotic. It has been established that some antibiotics suppress the development of the microflora, which is harmful to the organism, for instance the putrefactive and toxicogenic microflora; while the useful microflora (lactic acid bacteria and some others), among which there are species which synthesize vitamins needed by animals, is stimulated.

However, there are indications that the prolonged administration of antibiotics for therapeutic purposes may lead to a vitamin insufficiency as a result of the modification of the intestinal microflora. Other undesirable results may also arise. It has also been established that the systematic administration of antibiotics to ruminants, in the nutrition of which microbiological processes are of great importance, processes taking place in the stomach (or rather the compartment of the stomach which is called the rumen) eliminate the useful microflora and bring about severe disturbances of the digestion. In young ruminants, particularly calves during the earlier period of their life, when the microflora of the rumen does not yet play a very active role in their digestion, these disturbances are not observed.

Thus, the data of some authors, who point out the useful effect of the addition of antibiotics to the feed of animals, differ from the data published by other authors, who have not observed any such effect or who indicate that there is a harmful effect on the organism. It is not surprising that in a number of countries the sale of antibiotics to be used as an ingredient of the feed of animals is prohibited.

What has been said leads to the conclusion that our knowledge of the action of antibiotics when administered together with food is still inadequate. For that reason one must be very careful in approaching the problem on the utilization of antibiotics in the food industry. The most thorough and many-sided investigations on this subject are essential.

Very original and, from the standpoint of this discussion, very promising investigations are under way on the application in the food industry of the antibiotic properties of higher plants. Work on this subject has been done in the Soviet Union.

The juice of many higher plants, as has been shown by Soviet scientists, particularly B. P. Tokin, contains the so-called phytoncides, which have antibacterial properties (2). The phytoncides, just like antibiotics, comprise substances of the most diverse chemical composition. At present the chemical composition of many phytoncides has been investigated and these phytoncides have been isolated in the pure state.

It is obvious that in order to find out whether phytoncide preparations can be used as preservatives for food products one must investigate the effect of prolonged administration of these substances together with food. However, with reference to some food products, this problem is not of particular importance. For instance, it has been established that in the production of some canned preserves, one may effectively use the phytoncidic properties of the raw material from which these preserves are made.

Of particular interest in this respect are the investigations which have been conducted at the All-Union Scientific Research Institute of the Food Preserve Industry. These investigations established that phytoncides are contained in many vegetables and fruit as well as in some plants which are used as species (3). Thus, phytoncides are contained in tomatoes, carrots, beets, horseradish, parsley, onions, pepper, mustard, and coriander. The phytoncidic properties of plants depend on their species and age. The antibacterial activity of some phytoncides is more pronounced after heating.

Under the effect of the phytoncides of vegetables, the quantity of micro-organisms in canned preserves is reduced prior to sterilization. This makes it possible to reduce the temperature and extent of the sterilization of vegetable preserves by heating. The preserves obtained by the new method, which involves less rigorous conditions of sterilization, were found to have high indexes of bacterial sterility.

In many plants, for instance the onion, the volatile fraction of the phytoncides is of particular value. However, this fraction may be used up in a very short period of time. This circumstance must be taken into consideration in establishing the technological conditions for the treatment of the raw material in question.

The investigations described are of great significance from the standpoint of the fundamental principles involved. They made possible an entirely new approach, namely utilization of the antibacterial properties of the raw material being preserved, and at the same time demonstrated that on the basis of this principle one may achieve an improvement in the quality of production, increases in the efficiency of technological processes, and a reduction of the prime cost.

It is obvious that further work along this line is of importance. The attention of investigators must be concentrated on the selection and introduction into the food preserving industry of those species and varieties of vegetables, fruits, and other plants which are rich in phytoncides. Furthermore, the technological processes for the treatment of such raw material must be improved with the view to achieving maximum utilization of the phytoncides contained in it. It is also necessary to conduct work on the possibilities of using phytoncides in other branches of the food industry. From this standpoint, the capacity of some phytoncides to suppress the development of the putrefaction microflora which brings about spoilage of fresh fish is of great interest (4).

Soviet scientists are developing a new and original line of research dealing with the utilization of the phenomenon of interbacterial antagonism for the improvement of the quality of food products and of their stability during storage.

Organisms which exert an antibiotic effect are found within all groups of microbes, including yeast, lactic acid bacteria, acetic acid bacteria, and other species of microorganisms on the life processes of which many branches of the food industry depend. However, the products obtained with the aid of such microörganisms are often subjected to spoilage produced by extraneous microflora. Thus, sweet butter in storage loses many of its valuable properties as a result of the activity of putrefactive micro-organisms, lipolytic bacteria, mold fungi, and other microorganisms.

Soviet scientists have established that some strains of yeast have the capacity of suppressing microorganisms which damage butter (5). These strains of yeast may be used for the purpose of increasing the stability of butter to spoilage. A number of strains of lactic acid streptococci, which exert an antibiotic effect on the causative factors of the spoilage of butter, have been isolated from natural sources (6). If these strains are included in the production stock culture, which is used in the manufacture of sweet butter and which consists of a mixture of strains of lactic acid streptococci, one may suppress the development of putrefactive organisms and other harmful micro-organisms in the butter.

These investigations deserve serious attention. It is not impossible that one may discover among lactic acid bacteria culture which have not only antibacterial activity but also antifungus activity, and the property of suppressing bacterial phages. The discovery of lactic acid bacteria that have the last-mentioned property would be of great significance for the cheese industry, where the problem of the control of bacteriophage is of great importance. The phenomenon of antagonism between microorganisms may also be successfully used in other branches of the food industry.

In January 1954 the Institute of Microbiology, Academy of Sciences USSR, conducted a conference at which a report by N. A. Krasil'nikov was presented. This report dealt with the scientific basis of the application of antibiotics in the food industry and the prospects of such application. A number of other reports on research in this field was also presented.

The conference noted the importance of continuing work on the utilization of antibiotics and phytoncides, and the application of the phenemoña of antagonism between microbes in various branches of the food industry. In view of the great significance which must be ascribed to the elucidation of the action of antibiotics on the human organisms, when these antibiotics are used as preservatives for food products, the conference recommended that the appropriate institutes of the Ministry of Public Health USSR, particularly the Institute of Nutrition of the Academy of Medical Sciences USSR, take steps to investigate this problem.

It was especially indicated that there is a necessity for expanding work aimed at the discovery of new antibiotics derived from actinomycetes, mold fungi, and bacteria, as well as of phytoncides and antibiotics of animal origin, suitable for use in the food industry.

Introduction into the food industry of new antibiotics which are not used in medicine presents, as has been stated, definite advantages. It is obvious that the selection of a new antibiotic preparation for use in the food industry must be based on all the properties of this preparation. In medicine and veterinary medicine, an antibiotic usually serves the purpose of controlling a definite causative factor of some disease. In the food industry, on the other hand, one must as a rule preserve the product from the harmful action of a number of microorganisms which belong to the most diverse groups. It is therefore necessary that the antibiotic have a broad range of antimicrobial activity. Furthermore, an antibiotic which is suitable for use in the food industry must have an active effect on definite species of microorganisms not only in vitro, but also in the food product. It must be devoid of toxic properties, and harmless to the organism on prolonged consumption in small doses. It must not confer an unpleasant taste or odor, and must not produce any other undesirable changes in the properties of the food product.

Antibiotics with properties which are useful for the food industry can be found among the most diverse microorganisms. Bacteria, fungi, and actinomycetes are among them. Actinomycetes must be regarded as the most promising group of microorganisms in that respect.

As a confirmation of this may serve the results obtained in a search for antagonists effective against a number of species of microbes which produce spoilage of meat and meat products (7) Bact. Coli and Bact. proteus were used as test cultures; also Penicillium, Cladosporium, and Mucor fungi. A total of 806 strains of actinomycetes were tested. Of this total 244 strains, or 30%, exhibited the capacity for suppressing the development of either one or several of the harmful cultures used in the tests, while several had an effect on all the harmful cultures used. Antibacterial properties were exhibited by only 27 cultures, and antifungus properties by only 134 cultures, while 83 cultures suppressed the development of both bacteria and fungi present in various combinations.

One must assume that cultures which have antifungus properties will prove to be a promising source of antibiotics for use in those branches of the food industry where mold fungi have to be combated.

Antibiotics which have a low thermal stability and a relatively high degree of inactivation during storage with a food product may prove to be very useful. Such antibiotics would be very suitable for application in the canning industry and other branches of the food industry. Antibiotics of this type would lower the bacterial count of the crude material or intermediate products, and at the same time make possible the application of milder sterilization process. The subsequent inactivation of the antibiotics as a result of thermal treatment or storage would remove all possibilities of an undesirable effect of the antibiotics on the human organism.

It is understandable that introduction of antibiotics for use as food preservatives will necessitate precise methods for their quantitative determination on foods.

The problem of the application of antibiotics in the food industry is a new one which has not been investigated to any great extent as yet, and requires extensive study. For the successful solution to this problem the joint efforts of microbiologists, biochemists, technologists, hygienists, and representatives of other fields of knowledge are essential. In conclusion, one must point out that the expansion of work on new antibiotics will not only be of use to the food industry, but may result in discoveries which will be very valuable to medicine and agriculture.

BIBLIOGRAPHY

(1) N. A. Krasil'nikov, Application on Antibiotics in the Growing of Plants, Vestnik Akademii Nauk SSSR, vol. 24, no. 1, 1954, pp: 50-57.

(2) B. P. Tokin, Bakteritsidy Rastitel'nogo Proiskhozhdeniia-Fitontsidy [Bactericides of Plant Origin - Phytoncides], Medgiz, Moscow, 1942

(3) A. I. Rogacheva, Mikroviologicheskii Kontrol' Konservnogo Proizvodstva [Microbiological Control in the Canning Industry], Pishchepromizdat, Moscow, 1949.

(4) Iu. A. Ravich-Shcherbo, The Use of Phytoncides for the Preservation of Fresh Fish in Storage, Rybnoye Khoziaistvo, no. 10, 1949.

(5) V. M. Bogdanov, Application of Yeast Cultures in Butter Making, Mikrobiologiia, vol. 21, no. 3, 1952.

(6) Report presented by T. G. Romanovich at the Conference on the Use of Antibiotics in the Food Industry held at the Institute of Microbiology, Academy of Sciences USSR, on 19 January 1954

(7) Report presented by V. R. Mirzoyeva at the abovementioned conference.

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_y: R. Adelman
[Contents only]

lianko, G. I., Ed.

Zernovye i zernobobovye kul'tur na bogare.

[Cereals and legumes in dry farming in regions of insufficient rainfall.]

Gosudarstvennoe Izdatel'stvo Uzbekskoi SSR, Tashkent, 1952. 159 p.
59 Ze42

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Chirvinskii, I. A.

Novoe v Sel'skokhoziaistvennoe Nauke

[News in Agricultural Science]

Dostizheniia Nauki i Peredovogo Opyta
v Sel'skom Khoziaistve, 1954(1):72-75,
January 1954
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[In Russian]

NEWS IN AGRIBULTURAL SCIENCE

USE OF ANTIBIOTICS IN THE CONTROL OF INFECTIOUS DISEASES OF PLANTS

An important role in the solution of problems, set forth by the September Plenum of the TSK KPSS [Central Committee of Communist Party of the Soviet Union] before the workers of agriculture, is assigned to leading agrobiological science.

Workers of scientific institutions use every effort to exhaust all available and heretofore unutilized internal resources and to discover new possibilities that will rapidly increase the productivity of agricultural crops.

It is known that plants frequently become infected by various diseases which reduce their yielding capacity and cause enormous losses to kolkhoz production. Particularly great damages are inflicted by plant diseases caused by bacteria, pathogenic fungi and viruses.

Existing methods for the control of plant diseases are not always effective and at times produce no results whatever. Hence, an important medium in increasing the productivity of agricultural crops is the timely protection of plants against various diseases.

The scientists of the Institute of Microbiology, Academy of Sciences of the Union of the SSR have produced substances called antibiotics. These substances are used as medical preparations not only in medicine, but also in agriculture — in veterinary medicine, and in plant culture for the control of infectious diseases of plants.

Such a group of antibiotics includes penicillin, streptomycin, sintomycin and others. Investigations conducted by Soviet scientists have revealed that these substances can be produced by various little fungi and bacteria inhabiting the soil.

The works of the famous Soviet scientists, N. A. Krasil'nikov, and his staff reveal that antibiotics can be used for the prevention and treatment of infectious diseases such as wilt of citrus plants, gummosis of cotton, etc.

R. Mirzabekian, a Fellow of the Institute of Genetics, Academy of Sciences USSR, conducted tests with antibiotics on apricot trees infected by wilt on kolkhozes in the Armenian SSR. The tests produced positive results. [begin p. 73]. Injection of the antibiotic solution into the tissue of an apricot plant, or spraying of its crown precludes the further development of tissue infection. Following the spraying, the plants recover and in future continue to develop normally. Sick plants not subjected to treatment with this preparation perished completely.

Experiments conducted by S. Askarova (SOIUZNIKHI) [All-Union Scientific Research Institute of Cotton] under field conditions, on a 12 ha area of cotton crop treated with the antibiotic solution, showed a 40-60% decrease in plant infection by gummosis. At the same time, the cotton yield increased accordingly.

Experiments conducted on kolkhozes in the Uzbek SSR have shown that plant infection by gummosis reached 44% when the cotton seed had been treated with water, yet the number of infected cotton plants did not exceed 2.5% when the seed were treated with the antibiotic solution.

As regards their action, antibiotics are not inferior to granosan, NIUIF-1 [Scientific Research Institute of Fertilizers and Insectifuges], and in some cases they have obvious advantages over the latter. Thus, for instance, antibiotics accelerate the germination of seed, increase their sprouting capacity. Furthermore, they are not injurious to plant tissues, yet at the same time they kill microbes of infectious diseases. They remain active within the plant from 7 to 30 days.

N. A. Krasil'nikov, Corresponding Member of the Academy of Sciences USSR, for antibiotic treatment of agricultural plants recommends the injection of antibiotics into the trunk of a tree through an opening made with a drill, and spraying the crowns of trees and their leaves. Treatment of seed of agricultural crops before seeding is a more effective method. According to N. A. Krasil'nikov's data, destruction of pathogenic microbes, bacteria or fungi requires 5 to 100 ml of antibiotic solution, depending on the characteristics of the microbe and the plants. Antibiotics can also be added to composts. Antibiotic substances added to composts eliminate the incidence of infectious diseases of plants.

The report submitted by N. A. Krasil'nikov on this question at the meeting of the Technical Council of the Ministry of Agriculture, USSR, aroused the interest of specialists in the new discovery in the agricultural science. The meeting of the Technical Council noted concrete measures for the further study and adaptation in production of the new method for the control of diseases of agricultural crops.

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NEW TYPE OF FERTILIZER

(A Summary)

by
R. Adelman

At the end of 1953, the Technical Council of the Ministry of Agriculture, USSR, heard the report of Candidate of the Agricultural Sciences, N. N. Sokolov, on the use of "juice water" — liquid waste of potato starch factories — in fertilizing agricultural crops. The term "juice water" is applied to cell juice of potatoes diluted with pure water. The quantity of "juice water" which accumulates during the season when the starch factories are in operation on but one central belt of the Soviet Union, is large enough to irrigate field crops and vegetables covering an area of 14 thousand ha. The report includes a chemical analysis of "juice water" properties and shows the results of experiments.

In view of the importance of this waste product in raising the productivity of agricultural crops, The Technical Council, following a discussion, adopted a resolution that a new type of fertilizer be added to kolkhoz production at an early date.

Trans. 517
(In full)
By:
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Nikitenko, G. F.

Vnutrisortovaia i Mezhsortovaia Vegetativnaia Gibridizatsiia kak Metod Polucheniia porodno Uluchshennykh Elitnykh Semian Ovsa i IAchmenia

[Intravarietal and intervarietal Vegetative Hybridization as a method for obtaining genetically [porodno] Improved Choice Seed of Oats and Barley]

Selektsiia i Semenovodstvo, 17(5):35-39. May 1950
61.9 Se5

(In Russian)

517

INTRAVARIETAL AND INTERVARIETAL VEGETATIVE HYBRIDIZATION AS A METHOD FOR OBTAINING GENETICALLY IMPROVED CHOICE SEED OF OATS AND BARLEY

High genetic [porodnye] properties of choice seed, i.e. their increased vitality, adaptability to living conditions and, finally, their capacity to produce a higher yield, are the basic characteristics distinguishing these seed from the seed of mass reproduction.

Michurin's paramount agrobiological science has developed methods, already widely utilized in practice, aimed at increasing the genetic properties of the seed of perennial agricultural crops. These are, primarily, the methods of intravarietal and intervarietal crossing.

At the foundation of these methods lies the most important biological regularity contained in the fact that the crossing of organisms, even though there are slight differences between them, is biologically advantageous, for it results in the production of offspring with increased vitality, with a heightened capacity to adapt itself to ever changing conditions of external environment, while self-fertilization, particularly a protracted one, entails subsequent reduction of vitality, degeneration of offspring.

This regularity, first, as is known, noticed by Darwin, has been demonstrated in exhaustive experiments and has been developed further creatively in the works of I. V. Michurin, T. D. Lysenko and their numerous followers.

From the viewpoint of Michurin's teaching, the process of fertilization is a process of reciprocal assimilation-dissimilization, a process of incorporation, to a certain degree, of various sexual cells into a single body.

As Academician T. D. Lysenko teaches, the biological nature of the fertilization process is constituted by the process of reciprocal metabolism between sexual cells fused in one zygote. Fusion of distinct sexual cells into one [begin p. 36] cell creates a biological contrast in the single living body imparting to it greater vitality, greater adaptability to conditions of external environment.

However, the crossing of organisms with sexual cells, already at variance, is not the only means of increasing the vitality of the offspring of plant organisms; such organisms can be produced also through direction, by the will of man.

The process of forming in the organism sexual elements with different properties can be directed through substitution of appropriate cultural conditions and through vegetative hybridization based on variation in the metabolism of the graft components.

A vast amount of experimental work in vegetative hybridization of plants shows grafically and convincingly that transmission of hereditary properties of one strain to another can be accomplished without fusion of the elements, solely by transmitting the plastic substances; it shows also that the characteristics acquired by the organism through grafting are inherited by the seed progeny. Vegetative hybridization is accompanied by increased viability of the progeny.

Thus, in grafting, as well as in sexual crossings, organisms are formed with stronger biological contrasts and, therefore, with more vitality. Analogy in the conduct of vegetative and sexual hybrids can be understood only in the light of the well known theoretical hypothesis of Academician T. D. Lysenko[1], according to which the variation in plants prompted by changed environmental conditions of vegetative and sexual hybridization has one common basis.

Such a common basis is the organism's adaptation to changed conditions, changed nutrition, which lead to the formation of reproducing cell, internally heterogeneous, and contrasting in their potentials and requirements, i.e. a change in the type of metabolism definitely and specifically meant for the organisms.

* * *

The method for growing genetically improved choice seed, developed

[1] T. D. Lysenko - Agrobiologiia, 1948, p. 376

for most agricultural crops, and the fundamental principles of which are are stated in the article written by Academician M. A. Ol'shanskii and Candidates of the Agricultural Sciences, F. G. Kirichenko and E. T. Varentsa (see Zhurnal "Selektsiia i Semenovodstvo" No. 7, 1949) is based on the widespread use of intra-and inter-varietal crossing in free selective fertilization, in conjunction with expedient cultural practices for hybrid seed, and continuous selection for their improvement.

However, since the method for intra-and intervarietal crossing is not completely developed, it is recommended that the practically unalterable (former) scheme for growing choice seed be used for a series of the most important crops, such as oats, barley and others.

Yet, it is precisely these crops which, most of all, are in need of methods that will increase the vitality and improve the strain in the culture of choice seed.

It is known that, in protracted self-fertilization, the reason for depression of fertilization and, as a result, the decrease of vitality of the offspring is the comparative homogeneity of the sexual cells which participate in fertilization. In natural populations or in pure lines of self-pollinating plants which blossom more or less openly (as for example wheat), there is always the possibility of cross-breeding, which sharply decreases the harmful effect of inbreeding.

The specific characteristics of the blossoming of oats, and particularly of barley, nearly eliminate a similar possibility. It is known, for instance, that in intravarietal crossing of oats and barley by the methods used at the present time [begin p. 37] the number of grains formed is often quite negligible in relation to the number of castrated blossoms. The low percentage of success is a result of the circumstance that the pollen falls on the stigma of castrated blossoms in limited amounts. As a result, instead of obtaining biologically advantageous selective fertilization, there occurs limited pollination, fertilization with a negligible amount of pollen which is more an extremely forced than a selective fortilization.

The circumstance indicated should be noted also because of the fact that in barley, for instance, in cases in which it becomes necessary, for practical purposes, to resort to free backcrossing, the depression caused by limited pollination, due to pollen deficiency, destroys completely the favorable effect of crossing; the picture obtained resembles in many respects the process of fertilization seen in isolated self-fertilization. Hence the progeny of seed obtained as a result of such fertilization (in limited selection of pollen) frequently is characterized by poorer development and productivity.

As Academician T. D. Lysenko points out," the degree of embryo vitality ..... equals, in many respects, the degree of fertility. The less the fertility, i.e. percentage of fertilization of the ovicells,

- the loss also the degree of vitality of the seed obtained"[2].

Leaving the development of a more perfect method for intravarietal and intervarietal crossing an open question — though its urgent need for crops like barley, oats, etc. is obvious — and proceeding from the facts stated above, we make bold to propose another method for obtaining genetically improved choice seed of oats and barley. In our opinion, this could be the Method of Intravarietal and Intervarietal Vegetative Hybridization.

Up to now, specialized investigations have not been conducted for the purpose of inquiring into the effectiveness of intra-and intervarietal vegetative hybridization as a method of obtaining genetically improved seed. It is, however, known, for example, that in Academician I. I. Prezent's[3] experiments, intravarietal grafts of summer wheat Liutescens 62 proved more vital and, as a result, more productive than control (not grafted) plants. To a certain extent, this is indicated by the entire enormous factual experimental material on vegetative hybridization of plants.

A large number of works on vegetative hybridization of almost all field crops, including cereals, have ensured the development of a sufficiently simple and reliable hybridization technique. Of the many technical methods of vegetative hybridization of plants, in the case under investigation, we primarily refer to the method of embryo transplantation. The vast amount of experimental work accomplished by employing this method, and accumulated by the workers of the State Selection Station, permits its presentation without any fear that the intricacy and unadaptability of the technique of this method will preclude its application at the rate required.

Therefore, we suggest that, in growing genetically improved choice seed of oats and barley, the method recommended by Academicizn M. A. Ol'shanskii and Candidates of Agricultural Sciences, F. G. Kirichenko and E. T. Barenitsa, be extended by the addition of a new section: a nursery for intravarietal (intervarietal) graftings. Then, in place of the accepted use of ordinary seed, it will be necessary to plant in selection nursery seed obtained from intravarietal and intervarietal graftings. [begin p. 38].

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[2] Academician T. D. Lysenko - Three-year plan for the development of socialized kolkhoz and sovkhoz productive animal husbandry and the tasks of agricultural science. OGIZ — Sel'khozgiz. Moscow, 1949, p. 23

[3] Academician I. I. Prezent — The biological importance of double fertilization. "Agrobiologiia", No. 5, 1948

Culture of genetically improved choice seed of oats and barley based on intravarietal and intervarietal graftings can be visualized as follows:

a) Nursery for growing intravarietal (intervarietal) grafts (Fo);

b) Nursery for selection (F_1);

c) [v] Seed nursery (F_2);

d) [g] Preliminary propagation (F_3);

e) [d] Super-choice (F_4)

f) [e] Choice (F_5).

In the first nursery intra-and intervarietal grafts are grown. In conformity with the method recommended by the above authors, seed of the original components (parent forms) for grafting, should be taken from the more productive crops of the needed varieties. Transplantation of the embryo can be carried out by any of the known methods, but it is best to use the method of transplanting the dry embryo onto a dry endosperm. This method is technically easily accessible and, more important, it ensures a high degree of acclimatization of the grafts and affords the opportunity to begin transplantation work in good time, long before seeding time. In addition, transplantation by this method allows direction of the reciprocal influence of the graft components through variation in the amount of the assimilable plastic substances of the endosperm-stock (grafting on a double endosperm, seeding at considerable depth). Experimental work conducted by this method at the Mordov State Selection Station shows that the following technique is more acceptable:

In two dry grains of one of the graft components the embryos are cut with the blade of a safety razor (the incision must be made at an angle of 40-45° to the surface of the grain). Then a second incision is made in one of the grains on the side opposite the embryo. The incision on the surface are made with a safety razor in two perpendicular directions, after which [the grains] are steeped in water, best in warm water (room temperature). The action of the water causes the incised surface of the cut to swell up rapidly (in 1-2 minutes) and to acquire the consistency of glue. On endosperms thus prepared the transplantation of the embryo is performed; at first the embryo is glued to the endosperm on which two incisions had been made, and then the second endosperm is grafted onto [the first] from below.

With adequate practice and skill, one worker can easily perform 50-75 embryo transplantations per day. This will ensure accomplishment of the required volume of work without expending much manpower. The glued components keep very well and can be preserved in any type of container until seeding time; Petri dishes or those of Koch are best for this purpose.

The grafted grain can be sown in a hotbed, greenhouse or directly in the ground at the time customary for planting the given crops. In the latter case, the sector must be well tilled and fertilized — best with manure (50-60 T/ha) — prior to planting. For the purpose of increasing the influence of the endosperm, the planting depth for grafted grains should be increased up to 6-7 cm for oats and 7-8 cm for barley.

Each grain must be provided with the most favorable conditions for growth and development: optimal area of nutrition (10 x 30 cm), frequent supplementary feeding with a full mineral fertilizer (beneath the marker) watering — if necessary.

Careful phenological observations must be conducted during vegetation. Inspection (field and laboratory), customary in plant selection for selection nurseries: on the strength of development, productivity per plant, resistance to phyto- and entomological pests, stability of straw, etc.

Seed of the selected plants are seeded the following year in a selection nursery.

The subsequent work is carried on in full compliance with the requirements of the method recommended by Academician M. A. Ol'shanskii, Candidates of the agricultural sciences, F. G. Kirichenko and E. T. Varenitsa. [begin p. 39]

Using the method described, it will take a maximum of 2000 grafts to produce the necessary quantity of F_1 of rejuvinated seed (50 thousand); the culture of these grafts will require an area of 75-100 m^2.

With the amount of work involved, it will be easy to ensure the best possible care and observation of growth and development of the grafts, not only under conditions of State Selection Stations, but also in regional seed kolkhozes [raisemkhoz] and on sectors of experimenting farmers.

It is apparent that the success of cultivating intravarietal and intervarietal vegetative hybrids depends, in many respects, on the weather conditions of the year, the characteristics of the farm, the ability of the experimenters etc, and, therefore, the technics of the work adducted here must be considered as being schematic, as having a comparative importance.

Mordov State Selection
Station

Trans. 518
In full
By:
R. Adelman

Aleev, N. P.

Opyty po Izmeneniiu Prirody Pshenitsy
Putem Vegetativnoi Gibridizatsii

[Experiments in changing the nature of
wheat through vegetative hybridization]

Agrobiologiia, 1948(4):48-56
July-August, 1948 20 Ag822

[In Russian]

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EXPERIMENTS IN CHANGING THE NATURE OF WHEAT THROUGH VEGETATIVE HYBRIDIZATION

In this report we describe some of our experiments in vegetative hybridization of wheat conducted in the years 1940-1942. We concentrated on the transplantation of embryos of the seed of certain varieties upon the endosperm of other varieties and species of plants. Here are the results of the transplantation of embryos of wheat onto the endosperm of rice.

The choice of the embryo seed for a scion was based, first of all, on the fact that the embryo — the younger phase of plant life — is more easily influenced by external factors. It has been established that the embryo seed can develop not only on its own endosperm but also on a strange one.

The seed of wheat of Erytrospermum 0841 and Melianopus 069 were selected for the experimental work. The seed of rice of the Karatal'skii 8679 variety was selected for the stock (endosperm). After causing a slight swelling in all experimental seed, their embryos were cut off together with a small part of the endosperm (to avoid injuring the embryo). The wheat embryos were pasted with wheat dough to the endosperm of rice on which the small area obtained after removing the embryo expanded a little. The embryos grew firmly onto the rice endosperm. The total number of grafts made was 100.

The grain of wheat thus prepared were planted at the end of April in paper cups filled with sand and a slight admixture of soil. In growing the plants by the method described, the wheat embryos enjoyed the nutrients derived from the substances of the rice endosperm.

Almost all of them germinated, but from thence their fates differed.

Most of the sprouts perished early; some of them succeeded in developing one or two regular leaves and then perished, and only a few specimens developed to the point of the formation of generative organs. Some sprouts may have perished as a result of insufficient nutrition due to the loss of contact between the embryo and endosperm.

When the wheat had reached the phase of two-three leaves, it was planted in the field. Here it was watered in proportion to soil dryness and was fertilized three times with full mineral fertilizer. Nonetheless, the growth of the wheat was poor, the plants looked stunted and were easily susceptible to disease.

Up to the phase of heading there were left 16 specimens of wheat. A few of them formed branches, but most of them produced only one stem. Many stems formed spikes which fluctuated in length from 1 to 10 cm. [begin p. 49.] The spikelets of all spikes had scales of spikelets and buds, but the stamen and the pistils were absent from most of the bud. Although in fourteen out of sixteen plants the spikelet and bud scales were well formed, they began early to turn brown and to fall off, so that nothing but the core was left of the spike. Only one plant of the Erythrospermum variety (fig. 1) and one plant of the Melianopus variety produced one spike with kernels each. Fifteen kernels were found in the spike of the first plant and in the spike of the second plant — 8 kernels. The grains in both spikes were, generally very small and shrivelled, sometimes a little larger, but there was not a single normal, fully developed grain. The grains in the grafted Erythrospermum were considerably whiter as compared with the original form. The only Erythrospermum spike which produced grains was distinguished by a strong pubescene of the spike and flower scale, by porosity, by a large number of flowers in the spike — up to 11, counting the poorly developed and sterile flowers. Another spike of the same specimen disintegrated completely.

The fruit-bearing specimen of Melianopus (fig. 2) produced 3 spikes.

Fig. 1 - Left — Original form of Erythrospermum 0841.
Right — Grafted plant (Photo of 1940).

Fig. 2 - Grafted plant of wheat, Melianopus 069 onto the endosperm of rice.

One grain-bearing spike had abnormally curved awns and a more porous structure than is normal. [Begin p. 50] The number of flowers in the spike came to 9, but only 6 were fertile. Another spike, also abnormally porous, had no awns, was sterile and soon disintegrated; a third spike — compact, somewhat club-shaped, without awns and sterile.

Such were the hybrid plants of the wheat obtained in 1940.

To demonstrate the diversity of the plants grown from the seed obtained by vegetative hybridization, I shall describe the results of the crop from the seed harvested in 1940. As indicated above, only 2 spikes of two plants produced seed: the plant of Melianopus wheat yielded 8 grains, and the plant of Erythrospermum wheat — 15 grains.

These grains were sown in a greenhouse on April 21, 1941. In the case of Melianopus all eight grains germinated, in the case of Erythrospermum only ten. On April 30 the plants were transplanted in the field. On the Melianopus plants 2 specimens reached the stage of seed formation, of the Erythrospermum plants — 7 specimens.

The rest of the plants dried up and perished at certain stages of their development, or they produced sterile spikes. Harvesting of the plants was carried out on July 31, which means that the vegetative period lasted exactly 102 days.

I shall describe briefly some of the vegetative hybrids derived from Erythrospermum and rice. Plant No. 1, first generation (fig. 3). Height of the plant 88 cm, length of spike — 15 cm. Two spikelets are perched side by side at the bottom of the second, third and fourth rachises each; in addition to these three twin spikelets there are also 19 single spikelets. The total number of spikelets in the spike is 25 (including the three pairs of twins); grains — 106. Qualitatively all grains are satisfactory, they are white of pibment and barrel-shaped in form.

Plant No. 2 (fig. 4) reached the height of 82 cm including the spike. The spike contained 22 rachises. There were two spikelets on each — the first, second, fourth, fifth, sixth, seventh and eighth rachises; on the remaining fifteen rachises there was one on each. The number of grains in the twin spikelet ranged from one to five, in the upper six — none. [several words deleted] The 77 grains found in the spike described were poorly developed, thin, and of a white pigment.

Plant no. 3 had especially large leaves; the blades of the upper left — 30 cm long and 1.8 cm wide (at the part where the width is broadest). The blade of the leaf is thick and has sharply protruding veins. In the one and only spike, twin sterile spikelets were found underneath the second and fourth rachises.

The first and third single spikelet are likewise sterile. In the rest of the spikelets: four grains each (1 spikelet), 3 grains each (3 spikelets), 2 grains each (6 spikelets) and one grain each (8 spikelets); total number of grains in the spike — 33. The grains were full, large grains, but there were also small and poorly developed grains. Color and the form were the same as in the preceding ones.

A new characteristic which appeared in this generation is the distribution of twin spikelets on some of the rachises in a number of spikes. This characteristic was found in the progeny in the same incidence through the year 1946.

In 1941 new grafts were made. The embryos of wheat were grafted onto the endosperm of Karatal'sk rice: Tsezium 0111, Erythrospermum 0341, Melianopus 169 and Gordeiforme 0189. Altogether there were 400 graftings. The seeding was carried out on April 29.

On May 14, some plants with two leaves each were removed from the soil for inspection. A cyme could be clearly observed in the wheat embryo while it was in the ground. The part of its own endosperm which adjoins the cyme, left there when the operation was performed was completely absorbed; [begin p. 51] it had left on the cyme cavities and depressions containing reserves of nutrients. Nothing was left of the rice endosperm except the membrane; the wheat embryo had used up all the substances of the rice endosperm.

Fig. 3 -- First generation of hybrid wheat Erythrospermum grafted onto rice.

Fig. 4 -- First generation of hybrid wheat Erythrospermum grafted onto rice.

Only 16 plants reached the phase of fruiting, and, in addition, three plants developed with sterile spikes. Partly sterile spikes were found in fertile specimens; for instance, a spike of Erythrospermum 0341 had a total of 14 spikelets, yet only 5 of these yielded 6 grains.

In hybrid plants of wheat emerged properties which are absent in the ordinary plants of the original varieties. These new properties are unequally distributed not only among separate specimens, but also within the bounds of a single branch and even a single spike. I shall cite examples of certain variations.

For instance, in one specimen of Gordeiforme the upper internode bearing the spike is 8 cm long; it ends with a spike 4.5 in length; both, the internode and the spike were confined in a strong sheath 18 cm long. The spike, markedly bent, partly crumbled and sterile, emerged together with the internode that bears it not through the opening of the sheath apex, but through an opening in the side wall of the sheath. In another specimen of the Gordeiforme the spike came out only halfways and was sterile. There are perfectly shaped spikes which look normal, but are sterile.

[Begin p. 52] Alongside of the plants that yielded 6, 11 and 20 grains, there are spikes which produced 75 grains in 15 spikelets, 78 grains in 18 spikelets etc. At times, the kernels were very fine, thin and poorly developed, at times -- large and well filled out.

The kernels in the wheat referred to above as Erythrospermum 0341, were distributed in the spike as follows: in the first, fourth, eighth and ninth spikelets -- one grain each, in the seventh -- two grains, in the remaining nine spikelets no grains whatever. Spikelets with a varying number of flowers, up to eleven were found in some hybrids. The number of grains in the spikelets was just as varied -- from zero to seven.

Awns are subject to strong variation. In some Gordeiforme spikes the awns are very long (up to 23 cm), curved, and, at the top, strongly diverge in different directions -- the space between the tips of the awns measures 22 cm. In other Gordeiforme plants the awns project straight upward and rise above the spike only 5 cm. Finally, there was a plant with practically no awns on the spike: only in two spikelets the flowers had awns up to 4 cm in length, but in the rest of the flowers the scales taper off either with awns up to 1 mm, or into a sharp point. The awns in experimental plants of Melianopus wheat are also extremely varied as to length and pigment (from black color to white), they are of a different length and color even in one and the same spike, and even the same awn is differently colored in different parts.

An interesting phenomenon is the branching out of the stem. Branching was observed in experimental plants of two varieties: Melianopus and Gordeiforme. For instance, in Malianopus 069 (fig. 5) a side shoot emerges from the axil of the third leaf; the stem is 4 cm long; it has at its tip a spike 2.3 cm long, and including the awns -- 13 cm long. The spike bears a spikelet with eleven sterile flowers. On the same plant, a sedentary spike, 2 cm long and 1.8 cm wide at the upper and broadest part, emerged from the axil of the fourth leaf. The single spikelet had 7 flowers with awns up to 7.5 cm; the spikelet yielded two good and one sickly grain. The top spike of this plant (length 5 cm, and with awns -- 13.5 cm) is found on the upper internode, 4 cm long. The awns are yellow-green at the base, yet at the central and upper parts they are slightly gray-brown to brown and even entirely black (different awns are differently colored). Long awns are found only in the lower flowers, the rest have either none or some that do not exceed 7 mm. A spike that has 19 spikelets; one of them had seven flowers and yielded 5 grains. The rest of the spikelets were sterile.

Out of ten plants, Gordeiforme produced three plants with ramose stems. One of these plants is constructed as follows: from the axil of the third leaf emerges a stem with two internodes: the first -- 3 cm long, and the second -- 1.7 cm. The latter ends with a spike 3 cm long, with the awns

10 cm. The spike produced 8 small but full grains. From the leaf axil of this axillary shoot another stem grew out — 2 mm long — and ended with a spike 1.8 cm long and with the awns 5 cm long. This spike produced six grains. The top spike yielded 11 shrivelled poor grains. From three spikes of one stem a total of 25 kernels were harvested.

In another plant of Gordeiforme 0189 (fig. 6), the lower spikelet of the top spike lags 3 cm behind the others; the length of the rest of the spike is 6 cm.

The longest awns are those at the top, up to 4.0 cm; in the middle part they are considerably shorter, and the lower spikes have no awns. The spike yielded 19 grains. [begin p. 53] From the leaf axil a stem grew out ending with a 6 cm long spike. The spike had 15 spikelets which contained 48 grains. The largest number of grain in a spikelet was five; the length of the grains fluctuated from 4.5 to 8 mm. The longest awns were in the middle part of the soike; the spikelets at the top and at the bottom had no awns whatever.

Fig. 5 — Plant of the Melianopus 069 variety grafted onto the endosperm of rice.

Fig. 6 — Plant of the Gordeiforme 0189 variety grafted onto the endosperm of rice.

Among plants with non-ramose stems were found spikes which contained more than 70 kernels. Many spikelets of the same plants contained an increased number of flowers and grains.

All seed of the 1941 crop were sown in the field on May 11, 1942. The sowing was carried out with a spacing of 65 x 35 cm. The plants were harvested on August 29.

[Begin p. 54] An analysis of the first generation of wheat plants, spikes and apikelets of Erythrospermum 0841 produced a great variety. Regardless of the fact that Erythrospermum has long awns, all the hybrid plants of 1942 were nearly awnless; awns were found only in the five-six upper spikelets, yet not in all of them, and their length did not exceed 1.5 cm. The number of spikelets in the spikes fluctuated sharply; from eight to twenty-five. The same in the preceding year, twin spikelets were found on some spikes, i.e. not one, as is customary; but two and sometimes even three spikelets were located on one rachis. The number of these twins fluctuated between one and eleven (there was one spike on which 11 twins and 4 single spikelets were perched on fifteen rachises). More often than not these twin spikelets were sterile. The spikelet and flower scales were strongly depressed.

The number of flowers in the spikelet also varied: There were spikelets with three flowers, yet spikelets with eight flowers were also encountered. There were sterile spikes with but two-three grains, yet there were also spikes containing more than fifty grains (the largest number was 85 grains, and in a spikelet — 7 grains).

The progency of wheat grafted in 1941 was marked by the absence of ramose forms. Productive bushiness was varied; the number of stems with reproducing spikes fluctuated in individual plants between 1 and six; yet concomitantly, entirely sterile spikes were found in the very same shrubs. There were also plants which had sterile spikes only.

The number of kernels in different spikes is also quite varied; variations were observed also in the dimensions and in other properties of the kernels. Much variation was observed in the awns.

It should be noted that culture of the seed of Erythrospermum 0841, first obtained in 1940 by growing its embryo on the rice endosperm, was continued annually through 1946. Many variations survived seven generations. Figure 7 shows the multiformity of spikes obtained in the sixth generation (1946).

First of all, one notes the conspicuous absence of awns which, in the original form of Erythrospermum 0841, were twice as long as the spike. The spikes of hybrids are considerably longer than the spikes of the original form grown, for comparative reasons, under identical external conditions. Thus, the spikes of the original form are most frequently 8-9 cm long, yet the average length of the spike of a vegetative hybrid is 11-13 cm. In structure the spikes are dissimilar: there are spiles with twin spikelets, i.e. two spikelets (occasionally even three spikelets) are perched on one rachis. At times the spikelets are multiflorous and yield 4-6 grains, at times they are poor in flowers and yield but 2-3 grains; seen from the face, the first are considerably wider than the latter.

The spikelet and flower scales are thickly furred, this characteristic is less pronounced in the flowers at the top of the spikelet. The kernels are closely encased in the flower scales and do not spill.

Big differences are observed in the kernels. In the original form they are red, comparatively thin and long. Hybrid kernels are white with a slight yellowish hue, shortened and thicker (fig. 8). Equal amounts of the largest kernels of both forms were used for dimensional comparison: the length of kernels from the original form equalled 8.3 mm, and the width — 3.3 mm; In the hybrid form the corresponding sizes were: 7.3 mm and 3.8 mm. The maximum length [begin p. 55] of the kernels of the original form — 9 mm, maximum width — 3.5 mm; the corresponding sizes in the hybrid form: 8 mm and 4.5 mm. Therefore the weight of the selected largest seeds of both forms of wheat is fairly close: 1000 grains of the original form weigh

51 grams, of the hybrid — 55 grams.

Fig. 7 — Variation in the form of spikes of the vegetative hybrid Erythrospermum 0841 x rice in the sixth generation (1946).

If the form and structure of the spike do not as yet represent stable characteristics (multiflorous and multi-grain spikelets, the presence of twin spikelets on the rachis), then the form of the endosperm, its exceptionally white coloring and great softness and mealiness characterize complete stability and constancy transmitted by inheritance in the course of seven generations.

It is obvious from this report that the variations which are obtained in wheat plants, grown from embryos nourished by a rice endosperm, are extremely varied and extend to the generative organs as well as to the vegetative ones, while they become fixed in the seed offspring.

Among hybrid plants are found superior, economically valuable forms. For instance, plants, the grain of which have the absolute weight of 47 g, arouse considerable interest. The specimens which yield 5-6 reproductive spikes etc. are also valuable. It is our task to secure in the following generations these superior traits of altered plants.

On the basis of observations of the hybrids obtained, it is possible to draw certain preliminary conclusions as to whether those valuable properties which would be desirable not only to preserve, but also to strengthen in the new forms, are tapering out, or are progressing while the generations are in the process of development.

The overwhelming majority of agricultural characteristics, such as spike formation, high quality of grain (fulness, dimensions), productivity per plant among the better specimens, produce in the offspring higher indicators in comparison with the parent forms. The amount of grain in the spikelets increases,[begin p. 56] but the number of spikelets in the spike decreases somewhat, hence here is a decrease in the amount of grain per spike; but this does not occur in all plants.

It was mentioned above that culture of the progeny of a plant grafted in 1940 continued through the year 1946, and that it firmly retained many positive indicators.

Among the hybrid plants obtained are found quite a few shortcomings (sterility etc.), but there are also many valuable properties. Yet of the highest importance is the fact that by practicing vegetative hybridization it is possible to obtain offspring of the kind of plants in which sexual hybridization is impossible (rice and wheat). The practice of directed culture and selection of the best plants for vegetative hybrids will produce economically highly valuable forms with properties that will sharply differ from those in the initial material.

Fig. 8 — Top row —
Kernels of the original form of Erythrospermum 0841;
Bottom row —
Kernels of the hybrid form of Erythrospermum.

* * * * *

CONCLUSIONS

1. Introduction into the tissues of an embryo, that is beginning to develop, nutritive substances unadapted to its nature, diverts the course of the developmental processes from the normal and, as a result, new properties are formed in the plant cells; these properties appear in the form of distinguishing morphological and physiological plant characteristics.

2. Various new characteristics do not appear immediately in the year the grafting is performed, but they continue to form and develop in subsequent generations.

3. The instability of characteristics, the disappearance of former ones, appearance of new ones, indicate a mutability, an inconstancy of the inherited nature of vegetative hybrid plants.

4. Cells and tissues, the generative as well as the somatic, consist of multiple properties within the limits of a single plant, a single spike, spikelet, bud.

5. In our experiments in addition to the general disturbance of the hereditary properties of wheat, the hybrid plants were fed some of the properties of rice. We refer to the change in the color of grain from red to white, the compactness of flower scales, reduction of dimensions and color of awns, appearance of pubescence on the scales of spikelets and flowers, and some others.

Botanicheskii Sad AN Kazakhskoi SSR
Alma-Ata

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Osipov, A. E.

Opyty po vegetativnoi gibridizatsii zlakovykh

[Experiments in vegetative hybridization of gramineae].

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(In Russian)

EXPERIMENTS IN VEGETATIVE HYBRIDIZATION OF GRAMINEAE

The first experiments in vegetative hybridization of gramineae were begun [at the Riazanskaia Selektsionnaia Stantsiia] in the year 1938. To begin with, it was necessary to determine on a grafting technique. Oat plants of various ages were used for this purpose, beginning with the phase of development of the first surface node and ending with the phase of panicle emergence. Grafts were performed on a stem, a node, in a cut or cleft. Binding was accomplished with gauze, saturated bast and isolation ribbons. Of 173 grafts coalescence of the scion with the stock was secured in only four instances.

In addition, in a large quantity of oat grain, the embryo of one grain was transplanted onto the endosperm of another. In 4-5 days some of these grains showed signs of growth, but they soon perished for reasons unknown to us at that time.

The first year's work showed that grafting of Gramineae should be performed in the earliest phase of their ontogeny.

In the year 1939 the experiments were continued with attention centering primarily on the transplantation of embryos. Experimental technics were the following. Seed reserved for grafting were shelled of their hulls (work was conducted chiefly with hulled forms). Then the seed was placed on moist sand and covered with glass saucers. In approximately 20 hours (at sufficiently high temperatures — 12 hours) the seed of oats swelled up and showed signs of growing, and those of bromegrass — in 30 hours. After this, the embryos of stock and scion were cut off with a razor. It was established that the cut on the stock had to be larger than that in the scion, so that no part of the embryo might be left in the stock.

The embryos of the scion were carefully cut off and transferred onto the endosperm of the stock. The edges of the cuts were smeared with collodium.

Just as soon as the collodium was dry, the seed were again placed on moist sand under glass saucers. The sand under the saucers were always kept moist. The grafted embryos of oats began to grow in 2-3 days, and those of bromegrass in 4-5 days. Transplantation into pots [vazony] with soil was carried out 5-7 days following the grafting.

In a series of cases it was established that the embryos of the oat scion cut off carelessly (with the endosperm) did not grow onto the stock, but they continued to grow and, having been transplanted into containers with soil, they produced weak, but nonetheless fertile plants.

A 1949[x] transplantation of an embryo of smooth brome [Bromus inermis] onto the endosperm of oats produced 5 plants, including 4 from a combination of bromegrass and oats of the Moskovskii A-315 variety, and one from bromegrass and naked oats (Av. nuda).

[Begin p. 142] In the fall of 1939, the plants obtained were transplanted to the field, and in the spring of 1940 they were well advanced in growth. Their development proceeded satisfactorily, and, subsequently, control plants of bromegrass lagged behind the experimental plants by 10-12 days.

All plants obtained from grafted embryos were stronger than control plants. The variations produced by the influence of the stock affected not only the general character of the plants, but also their separate parts and organs. The panicles and straw of these plants looked more like oats (fig. 1). The number of spikelets in their panicles was also larger.

The plants obtained from the graft of a bromegrass embryo onto the endosperm of naked oats, had a softer leaf than the scion.

The axil of straw was naked. Furriness was negligible beneath the axil, yet above it, it was sharply promounced. Spikelets of the panicle were larger and they contained more flowers than are found in smooth bromegrass (fig. 2).

(x) Translator's note: it seems that 1939 was meant instead of 1949.

The kernels, with respect to pigment, resembled broomgrass, the pigment of the hulls was light. The internal hull of the flower was nearly light. The external flower hull was larger than the kernel and looked as though it enveloped it, and was easily removed (fig. 3). Among the grain of this plant were found specimens, the kernels of which hulled easily from the flower chaff. The stem of the grain is markedly shorter and thicker than in broomegrass.

The grain of plants obtained as a result of grafting the embryo of smooth broomegrass onto the endosperm of oats, Moskovskii A-315, were fuller and looked as if they had been pushed through the flower hulls which did not join either at the top nor at the sides.

The grain obtained was not uniform. The size of the grain, their form, and the character of the flower hulls differed rather strongly within the limits of the same combination and even on the same plant.

[fig. 1] — Left:
Panicle of smooth broomegrass;
Right:
Panicle of oats, Moskovskii A-315;
In center:
Panicle of plant obtained as a result of grafting the embryo of smooth broomegrass onto the endosperm of oats, Moskovskii A-315.

[Begin p. 143]

[fig. 2] — Left:
Spikelet of smooth broomegrass;
Right:
Spikelet of _Avena nuda_;
In center:
Spikelet of plant obtained as a result of grafting smooth broomegrass onto the endosperm of _Av. nuda_.

On the basis of the factual material obtained, we have arrived at the conclusion that, regardless of the short space of time in which the grain embryo of one plant was nourished by the ready plastic substances of the endosperm of another, there occurred marked variations in the characteristics of the scion exposed to the influence of the stock. We were, however, unable to tell then whether or not these variations will be transmitted to the following seed generations. During the patriotic was these experiments were discontinued, and they were resumed only in the year 1947 with the partially preserved material. The greatest interest centered on the transplantation of the barley embryo.

In the year 1941, the embryo of Pallidum 45 barley was grafted onto the endosperm of the trifurcatum form of barley. As a result, a plant was produced, the spikes of which included grain with hulls and naked grain, and as a rule, the naked grain was found in the lower part of the spikes. In a single spike one could encounter awns that were normal in Pallidum 45, shortened awns, and awns that looked as if they had been fractured beneath the axil.

In the spring of 1947, the seed obtained was seeded in the field separately, naked grain, grain with changed awns, and hulled grain with awns normal for Pallidum 45. All of them produced normal germination, but the plants obtained from naked grain were completely destroyed by fleas and the swedish fly.

The hulled seed with changed awns produced plants with multiple rows of awned spikes. Individual plants had soft awns, and one plant had ramose spikes.

Hulled seed which had awns normal for Pallidum 45 produced: one plant with changed awns, the grains in the lower part of the spike bearing awns 5 cm long and ending in a prong [furca], the rest of the grains having long awns with a fracture at the center, all grains were hulled; five plants with rough awns; the grain was hulled, naked and semi-naked; four plants with shortened awns and naked grain; one plant with long awns and naked grain; [begin p. 144] one plant with short awns, 95% of the grain hulled and 5% naked.

[fig. 3] — Left:
Grain of smooth broomegrass;
Right:
grain of Avena nuda with flower hulls;
In center:
Grain of plant obtained as a result of grafting the embryo of smooth broomegrass onto the endosperm of Av. nuda.

In the year 1948, the grain of these plants were seeded separately in the field. Thus we got a third generation from the grafts. As a result of an analysis, a large variety of form was established in the third generation (fig. 4).

Variations formed in the first generation were transmitted to the next seed generations. In the following generations a splitting up is observed in the characteristics.

Thus, a plant, the spike of which had short awns and long prongs, produced in the progeny 5 morphologically different groups of plants (fig. 5).

Hulled grain with altered awns were selected from first generation hybrids, and in 1947 their embryos were grafted onto the endosperm of trifurcatum for a second time. 30 graftings produced but one plant, which, however, cannot

[fig. 4] -- Spikes of plant F_3 obtained as a result of grafting the embryo of barley Pallidum 45 onto the endosperm of trifurcatum.

[begin p. 145]

[fig. 5] -- Progeny of spike which had long prongs and short awns.

be wholly attributed to the imperfection of transplantation technics.

As a result of repeated grafting, a plant was obtained which had sturdy straw, a broad leaf blade, many rows of awned spikes and naked grain. The awns were coarse, notched, 10 cm long. The spike contained 68 grains, the spikelets were trifloral.

The seed of this plant were seeded in 1948. The plants that developed from these seed had the same morphological characteristics noted in 1947.

Thus, the form of barley obtained by grafting the embryo of Pallidum 45 barley twice onto the endosperm of trifurcatum has the characteristics of the scion -- coarse long awns and tall straw, as well as those of the stock -- a broad leaf blade and naked grain.

To introduce oat varieties resistant to loose smut [Ustilago avenae], we grafted in 1939 the embryo of Avena brevis onto the endosperm of the Moskovskii A-315 variety, and in 1941 -- embryo of the variety "Pobeda" onto the endosperm of Avena brevis.

In both cases, no morphological variations were discovered in the year of grafting. Nonetheless, the material obtained from the graftings was seeded again the following years. As a result it was established that variations in size and coloring of grain began to appear, in the first case -- in the

3rd year, and in the second — during the 2nd year (see table on page 146).

The experiment conducted shows that variations resulting from grafting cannot always be seen in the year the grafting is performed. Moreover, they may not appear even in the second year of re-seeding. This can lead the researcher to the false conclusion that it is impossible to obtain vegetative hybrids. Meanwhile, in the second, and sometimes even in the third year following the grafting, the variations become evident.

In the given concrete case, variations in the embryo exposed to the action of the stock endosperm occurred, positively, in the year of grafting. But they, obviously, affected a small section of the embryo cell, and, therefore, were unable to appear in the first generation.

White and brown grains selected from a variant of the 1947 yield of Pobeda variety on Av. brevis were seeded separately in the year 1948. As a result, the white grains produced plants with white grain, and the brown ones — with brown grain. [begin p. 146].

Characteristics of grain by year of consecutive seeding

Variant	Year of grafting	Crop years			
		1940	1941	1947	1948
Embryo of Av. brevis oats grafted onto endosperm of Moskovskii A-315 variety	1939	Variations: none	Grain white and brown	Grain small, gray, a few large and white grains	Grain en Mass. gray, separate grains, large, white
Embryo of oat variety Pobeda grafted onto endosperm of Av. brevis	1941	---	Variations: none	Grain large, white and brown	Grain large, en mass brown, separate grains white

No less interesting was the case of partial variation in embryo cells under the influence of the stock (endosperm), which we observed in the transplantation of the embryo of Pobeda variety onto the endosperm of the variety Golden Rain. Here also no variations were noticed in the year of grafting, and in the following year the grafting was repeated. Fifteen plants were obtained and it was established that the color of their grain varied. In addition, a a sharp variation in the color of grain was observed on a single plant, except that it appeared in different stems. Thus, in 14 plants out of 15, the grain of the center panicles was yellow, and only in one case it was a pale yellow, yet on the side panicles it was white. Consequently the pigment of grain varies in one and the same plant.

* * * * *

CONCLUSION

On the basis of the material acquired on vegetative hybridization, we are of the opinion that vegetative hybrids of cereals can be obtained perfectly by embryo transplantation.

Experiments show that the embryo of grain of one form, feeding on the ready plastic substances on the endosperm of another form, changes its hereditary properties in favor of the latter.

However, the variations are not always observed in the year the grafting is performed. Moreover, changed conditions of embryo nutrition may produce a different effect on the same plant.

Changes in the scion in favor of the stock depend on the length of time the embryo feeds on the plastic substances of the stock, and on the degree of influence exerted by substances of the changed section of the embryo upon the general process leading to the formation of reproductive cells.

In our experiments, repeated grafting produced, as a rule, sharp changes. the most profound action exerted by the stock upon the scion was revealed in the reproductive organs and transmitted to the following generations.

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Riazanskaia Selektsionnaia Stantsiia

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s Ozimoi Pshenitsei

[Vegetative Hybridization between Rye and
Winter Wheat].

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VEGETATIVE HYBRIDIZATION BETWEEN RYE AND WINTER WHEAT

[Fundamentals of Topic]

The study of varieties and forms derived by the Iaroslav State Selection Station from the universal collection of Vir [All-Union Institute of Plant Industry] and from other localities of the USSR has demonstrated that it is an illusion to anticipate the finding of ready-made, highly winter-hardy forms fit for production in the Iaroslav Region.

In three years of work at the station (from 1937 through 1940), more than 700 specimens of the 1029 planted in the original selection nurseries perished completely while still in the ground, and the rest proved inferior, according to a series of economic and biological characteristics.

Being familiar with I. V. Michurin's work on vegetative hybridization of fruit trees, we decided to apply the same method to selection of Gramineae.

Methods and Technics of Vegetative Hybridization of Gramineae

The Iaroslav State Selection Station had to conduct experimental work independently, in order to develop grafting technics of Gramineae (1940-1941). The work of grafting began August 15, 1940 and lasted until May 15, 1941.

The grafting was carried out by two technicians, under the supervision of the author of the present article, and involved various modifications in the characteristics of the experimental objects [Gramineae species used].

We searched for the following experimental conditions: [begin p. 32]

1. Stages of development of the graft components at which normal coalescence of the latter is ensured.

2. Best method of incision of plants to be grafted (form, angle and direction).

3. Places of incision on graft components (surface level of incision).

4. Methods of junction of coalescent plants.

5. Substances strengthening the junction of components and ensuring their better coalescence.

6. Optimal conditions of external environment for the grafting and post-grafting period to ensure better coalescence (temperature, light, moist chamber).

Without describing in detail the progress of our experimental work, we shall pause here only to consider the conditions we have found to ensure normal coalescence of the graft components -- rye and wheat.

It was found that one-centimeter shoots are best for grafting. Under laboratory conditions, (at a temperature of 16-18°C on moist soil) this stage of development is reached in rye on the 4-5th day after seeding, and in wheat on the 5-6th day. To give the graft plants an equal change, rye was seeded 24 hours later than wheat.

The advantage of the given developmental phase of stock and scion for grafting, we perceive in the weakness of differentiation of the tissues and in their postembryonic character. The moment shoots have reached the growth of 1.5 cm, the percentage of actual coalescence drops rapidly. Yet unstable coalescence of the components fails to ensure a completely normal cycle of development of the vegetative hybrid.

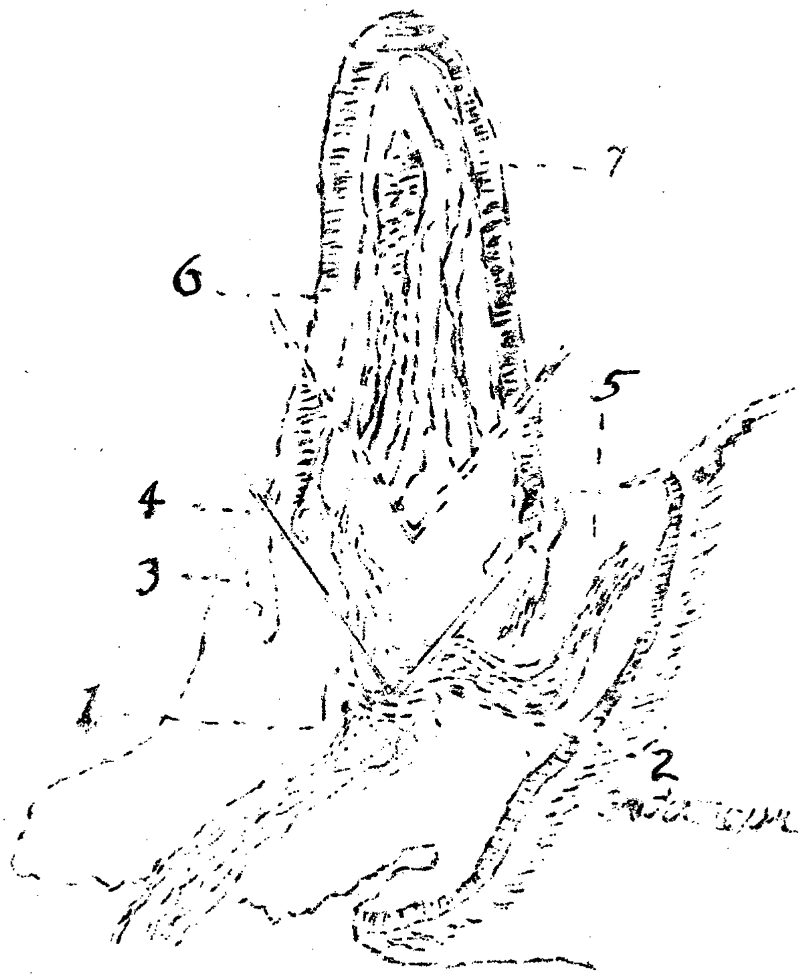

Fig. 1 - Internal structure of one-centimeter shoot of Gramineae (rye and wheat): (1) - central embryonic rádicle, (2) - zone of actual coalescence, (3) - epiblast, (4) - Axillary (supplementary) bud at point of growth, in embryo, (5)-cyme, (6) - first leaf, (7) - coleoptile. [The work ENDOSPERM appears under (2)]. [Begin p.33]

Rye stocks and wheat scions have the structure depicted on fig. 1 when they are in the phase of one-centimeter shoots.

In natural shoots the "zone of division" between the root system and the stem can be easily defined with the naked eye. This zone is very important in the performance of wedge-shaped [klinovidnyi] incisions on stock and scion. The base of the wedge-shaped incision of the scion, cut off in a manner that it retains the largest possible part of the first leaf including the tillering point, must have the lower point of the junction precisely in this zone. No real coalescence of the components will occur, if the incisions of stock and scion are either too high above this zone or too low beneath it, but instead other types of coalescence will take place: a) "dynamic" and b) coalescence with the formation by the scion of its own root system. The latter types do not ensure coalescence between the components whereby the scion could utilize the root system of the stock of rye during the entire ontogeny, since, to begin with, the life span of such hybrids does not exceed 1-2 months. However, in the second type of coalescence, the wheat scion will utilize only the endosperm of the rye stock and later, having developed its own root system, it will become self-sufficient as regards nutrition. The reason for the origin of such two types of component coalescence can be explained by the tongue-shaped incisions on stock and scion, performed either too high or too low.

Fig. 2 - Method and angle of incision of sprouts of stock and scion.

In the case of an elevated incision of the sprout in the stock, the first leaf with the tillering point remains in the stock and develops into a distinctly rye plant which a certain lapse of time throws off the scion, feebly grown onto it. In the end result, it is immaterial just how the cutting-off of the scion had been performed in relation to the "zone of actual coalescence". Nonetheless, in such a case, the cutting-off of the scion either too high, normally, or too low does influence the character of the post-grafting development of the components. It determines still other types of coalescence and component development to be discussed below.

If the sprout of the stock has been cut too low, its first leaf (with the tillering point) has been taken out of it, and the low cut scion, that replaces it has at the base of its tongue-wedged incision its own first leaf with the tillering point and a particle of root tissue. This particle of root tissue of the scion develops into a distinct root system of the scion, regardless of the fact that the coleoptiles of both components coalesce normally. This explains the above mentioned type of component coalescence. It has the drawback that, in its particular case, the influence exerted by the stock on the scion is temporary, and takes the form of a rye endosperm being utilized by a wheat scion. The reconstruction of the physiological basis is poor and loses its effect within the next 1-2 years.

In this type of component coalescence, the morphological variability pertains only to the grain and also disappears rapidly.

Fig. 3 - Method of fastening graft components with paraffin.

Equal in importance to the zone of actual coalescence of the components, and to the orientation as to how their cutting off affects the zone, is the angle of incision of the stock and scion shoots. We have established the optimal size of the incision angle at 50-55° (fig. 2).

If this size is reduced, then the base of the wedge takes the shape of the point and thus no longer houses the significant part of the first leaf including the tillering point of scion and stock. If, however, they are left in their natural position when the incision is made, then they regenerate into distinct plants displaying the characteristics of coalescence and subsequent development of vegetative hybrids.

[Begin p. 34] An angle of incision more blunt (above 55°) determines the impossibility of fastening the components at their junction, since the coleoptile of the stock is then left at less than 2 mm which is insufficient for component cementing, so exceedingly important to coalescence. Yet, if the graft components were cut higher at the given angle (so their coleoptiles would reach 3 mm), then the base of the first leaf with the tillering point would not be cut out. In such a case component coalescence would proceed differently with regard to type, and conditions needed for normal grafting would not be created.

Following the preparation and selection of sprouts of the stock and scion, they were taken carefully from the box, and each pair was cut separately. The cutting was performed with a sharp blade of a safety razor in a place well lighted with either electric or natural lighting. The cut-off scion sprout was immediately transferred to the place on the stock specially fitted for it. After this [the scion] must be pressed with one's finger against the stock, and the junction of the cuts must be inundated with melted technical paraffin. From this moment onward it is best that two people perform the grafting operation: one presses the scion to the stock, and the other pours a drop of melted paraffin on the junction of the cuts with a dissecting [proparoval'noi] needle. The paraffin congeals rapidly, covering the entire junction of the cuts and firmly fastens the grafted components (fig. 3).

Following the grafting, the plants are planted in separate boxes filled with soil sterilized with boiling water. The top layer of soil in the box is carefully smoothed down and rolled out, so that following the planting of the grafted plant, its incision junction covered by paraffin would be located on the surface immediately above ground. This is necessary for purposes of observation of post-grafting development and determination of coalescence type.

It is precisely the character of coalescence of the grafted components that determines the specificity of subsequent development and the degree of ultimate reciprocal influence between stock and scion.

The coalescence character of graft components is determined not only by the successful incision of the graft components, the size of the incision angle, and the orientation of the wedge in its relation to the "zone of actual coalescence", but also by the selection of the stock and scion. In addition to conformity of age, it is essential that the coleoptile diameters and the internal structure of the first leaf of the components coincide. Non-concurrence of the diameters of stock and scion coleoptiles is, as a rule, connected with the nonconformity of their first leaves and tillering points in their general contours, as well as in the vascular conductive system of the leaves.

Nonconformity of the given elements of the stock and scion cause either complete non-coalescence of the latter, or entirely different types of coalescence: 1) partial or chimorical, 2) false, 3) double. Of all the given types, it is only "double coalescence" that ensures a radical reorganization of the nature of the scion, while the two other types of coalescence mentioned determine the development of abnormal or chimeric plants with a life span that does not exceed 1-2 months. Later such plants either perish or develop a single stock — rye.

As a result, of the enumerated six types of coalescence of graft components, [begin p. 35] only two types of coalescence reproduce real vegetative hybrids. However, each of these two types of coalescence produce different types of hybrid plants. Therefore, we cite the characteristics of all six types of coalescence of graft components of the rye stock and the wheat scion, according to the grafting technics and methods developed by us.

Fig. 4 - Scheme of incisions of stock and scion that ensures normal coalescence between rye and wheat:
(1-3) - shoot of the scion with the tillering point at the base of the incision (3);
(4) - area of stock incision.

Fig. 5 - Morphological variation of a vegetative hybrid as compared with the original forms: Viatka rye and Diurabl' wheat.
From left to right — Viatka, Diurabl', and vegetative hybrid.

1. Normal or Actual Coalescence Type.

This type coalescence is obtained, if the grafting conditions enumerated by us are observed. Angle of incision of graft components of stock and scion 50-55°. At the base of the wedge (at its edge) of the scion must be located the first leaf including the tillering point of the scion (fig.4). The wedge-shaped incision of the scion and stock must be strictly oriented with respect to the facet of division of the roots from the stem of the shoot or "zone of actual coalescence" of the components. The diameters of graft components must coincide not only in the coleoptile, but also within the internal contours of their first leaves (see fig. 1, 2, 3). The vascular conducting system of the first leaves of both components must also coincide.

Fulfillment of these conditions establishes complete contact between the corresponding parts of stock and scion, as a result of which complete coalescence of the components occurs within 4-5 days, with common metabolism during the entire ontogeny.

[Begin p. 36] Identification of "actual coalescence" type and conduct of hybrid generations. Actual coalescence can be determined by the following indicators:

The incision junction inundated by paraffin rests evenly on top of the soil (the same as when the plant was planted after the grafting).

On the 4-5th day the first (green) leaf of the scion emerges from the coleoptile of the scion and in future, continues to develop normally. In comparison with the non-grafted stock and scion, growth is strongly retarded. The horizontally arranged rootlets of the rye stock continue to grow longer and to develop; this becomes apparent if they are broken off carefully from the ground and one of the rootlets is placed inside a severed stalk whose diameter at the opening is larger than the diameter of the rootlet.

The type of plant that develops is morphologically and physiologically essentially different from the original parent forms, and possesses special regularities arising in the subsequent development of its future generations (fig. 5).

The rye stock fails to develop a single fast-growing shoot [podgona] until the end of the hybrid ontogeny. The scion forms a bushy growth which is of the rye type, according to the number of the general as well as the productive stems.

On reaching maturity the grain has a clearly intermediate form and structure and at times surpasses the parent forms by its size. It has a deep furrow on the ventral [briushnoi] side and a transverse corrugation on the dorsal side. In the zero generation the straw resembles more the straw of the rye stock. Yet in the following generation (in F_1), when the hybrid plant develops on its own roots during the entire ontogeny, the length of the straw is shorter by 40-50 cm under normal field conditions of development. Spike and structure of the straw also undergo essential changes in favor of the scion, but the color of the ripe straw and its girth are sharply distinct from the scion as well as from all other varieties of wheat.

On the whole, the grain in F_1 undergoes a sharp change for the worse: in our experiments the absolute weight dropped from 42 gr. in F_0 to 9-10 gr. in F_1. By its external appearance, the grain of this generation remained a sharp intermediate between the initial parent forms.

The stock of rye transmits the gray-green color of the grain with a transverse crimp on its dorsal surface. In chewing the grain one perceives the taste of rye. Segregation of new forms of plants starts with the first generation in small amounts (less that 0.01% of the entire generation). The hybrid deviatives [vyshchepentsy] are of only one type each year; but morphologically they are completely different in different years. Until 1945 (up to F_4) our vegetative hybrid of 1940/41 had a preponderance of hybrid derivatives of the wheat and the intermediate type; in 1945, however, in the fourth generation of the hybrid, there appeared a "splinter-hybrid in a considerable quantity (up to 0.01%) from the entire generation. The straw of the latter was 45-50 cm taller than that of the hybrid plant. Morphologically, the spike also was rye-shaped and completely sterile.

The hybrid derivatives of the wheat type produced but two fertile forms — in 1942 and in 1946. The first proved of little value economically, but the hybrid derivative of 1946 displayed a series of economically and biologically valuable characteristics (high winter hardiness and productivity in 1946/47). This hybrid derivative propagates.

From 1942 up to the present, the morphology of the spike and of the plant as a whole has undergone no essential variation in the given vegetative hybrid, with the exception of some variation in the length of the hybrid's straw in certain years. The grain, however, continues to improve with each successive generation from F_1 (1942) until the present time.

Practicing selection since 1945 and cultivation of the hybrid on a high agricultural plane was responsible for raising successfully the absolute weight of mass reproduction grain (unsorted) to an average 37 gr, with their physical properties being greatly improved. In 1947, when the basic form of the vegetative hybrid was fully stabilized and the hybrid derivative was absent from the plants as a whole, there evolved 10 new derivative forms among the grain. The latter differed sharply from the mass reproduction of the hybrid of the 1947 yield, as well as among themselves.

They were developed by individual selection from 30,000 typical spikes of the hybrid which has been selected preliminarily from mass reproduction and had been threshed spike by spike, in a laboratory. Variation of one form from the other, as well as from the grain of mass reproduction was distinguished by the following characteristics: [Begin p. 37]

a) the color of the grain varies from red to reddish gray, then to yellow, and finally to white;

b) the structure of the grain varies from pure glassiness to intermediate [promezhutochnuiu] and finally to a starchy one;

c) the absolute weight of grain varies from 37 gr for the entire given reproduction of 1947, to 62 gr in some newly isolated forms;

d) the shape of the grain in hybrid derivatives varied from short to normal and to long.

The extent of variability in the hybrid derivatives among grain is, on the whole, no less than the variation occurring in this characteristic in the individual varieties of diverse ecological origin.

The common characteristic of the grain in these hybrid derivatives and of the basic hybrid form is merely the polyspermy of grain found in the spike (from 52 to 90 grains), while the deep furrow noted earlier — a negative characteristic which so persistently accompanied the grain of the hybrid in every generation — was not found in all hybrid derivatives.

This variety of form in the grain of the hybrid derivatives of the 1947 vegetative hybrid shows clearly how deeply the hereditary nature of wheat plants is altered by the method of vegetative hybridization. It is possible that this specificity emerged in forms newly isolated in 1947, will remain a hereditary [characteristics] in subsequent generations, and not only with respect to the grain, but also in the plant as a whole. The latter we are able to confirm by the fact that the seed of the given hybrids derivatives sown for the purpose of forced propagation under laboratory conditions produced a variety of sprouts. Under analogous seeding conditions and environment as a whole, some forms produced sprouts by 1.5 full days earlier than others. However, in point of character of plant structure, rate of growth, and development, each form of the hybrids derivatives was notably different from mass reproduction and also from one another.

We are deeply convinced that the hereditary basis of Gramineae is so profoundly altered under the influence of vegetative hybridization that in the course of generations there evolve new forms of plants even in instances when the seeding had been carried out in the form of pure lines (by family). Hence vegetative hybridization is interesting not only from the production aspect, but also from the point of view of variety formation within the confines of the family Gramineae.

Fig. 6 - Process of development of a vegetative hybrid of the "double coalescence type".
From the left —rye, from the right — wheat.
On fig. 1, left, is seen a gap and regeneration of the coleoptile of the stock into a distinct plant.
On the last figure, right — coleoptiles have been removed artificially so that the general base of the hybrid could be seen.

2. Type of Double Coalescence of Components

In regard to method and technics, the characteristic conditions for the given type of coalescence are the following: similar to first varient, the incision angle in the stock is made a little larger (by 10-15 degrees) than the incision angle of the scion, when stock and scion components are being cut off. The scion, put in the wedge-shaped pocket of the stock, fails to fill it out and leaves an empty gap (as large as the difference between the incision angles in the stock and the scion). The given gap is left only on one side, while the other side of the components' junction (as well as their first leaves) was arranged to match perfectly at the junction (fig. 6). [Begin p. 38]

Fig. 7 - Left — hybrid of "double coalescence": (1) - wheat; (2) - rye; (3) - grain of rye, (4) - root system of rye.
Right — hybrid of "single coalescence": (1) - wheat; (2) - grain of rye; (3) - root system of rye.

Paraffin coating of the components is here applied solely on that side of the component junction where there is no gap between the coleoptiles of stock and scion. Coalescence occurs on the side of component coleoptiles that had been fitted together on the opposite side of the gap. Here coalesce also the parts of the first leaves with the tillering points of the components. Yet the other side, the one with the gap, which had not coalesced and had not been inundated with paraffin, produces germination in the coleoptile of the rye stock which regenerates into a distinct plant, developing side by side with the wheat scion within the limits of one hybrid plant. Double coalescence is produced in this manner: the wheat scion on the stock and root system of rye grows together "in the zone of actual coalescence", and in addition maintains a lateral contact with the stock of rye which had regenerated into a plant on the side with the gap, from one half of the stock coleoptile (fig. 7).

In their further development, the rye and wheat halves of such a "chimerical plant" exert great influence on one another, as a result of which a diminishing of the differences in the color of leaves and in structure of stem is noted.

The grain is of an intermediate type, while its color is partially derived from rye, but differs essentially from that of rye. There is an even greater deviation of the color of these grains, as well as of their form and structure, from the grain of the scion grown on its own roots.

Frequently the given type of hybrid plants (double coalescence) is formed also by other means: a plant of rye stock develops not by regeneration from the stock coleoptile in the lower part of the gap, but from the sprouting of the first leaf of the stock, left in part in the stock while a shoot was being cut off at the time of grafting (see fig. 1). A certain part of the first leaf of the stock always remains when incisions are made by our method. [begin p. 39] However, in component coalescence of the first type (actual single coalescence), this part of rye, having coalesced is depressed by the scion and fails to regenerate into a rye plant. Yet, in the event of "double coalescence", the part of the first leaf left in the stock begins to sprout on the side with the gap and develops into a distinct plant. The latter, however, maintains complete organic relationship and has common metabolism with the scion through the coalescence at the other side and at the lower part of the incision.

In the zero generation, the seed of vegetative hybrids of the first and of the given types of coalescence are, in all characteristics, essentially different from their parent forms (Sandomirka-Al'bidum and the Viatka rye), as well as from one another. In addition, a higher degree of hybridity is acquired by the seed of "double coalescence" hybrids which, during their formation, had been exposed not only to the influence of plasma and root nutrition of the rye stock, but also to strong action of the leafy surface of the stock. If parts of a hybrid enjoyed common metabolism then the latter [leafy surface] performed the role of a michurin mentor, which was graphically expressed also in the morphological specificity of the hybrid seed. The latter showed a strong change in all their basic characteristics, such as: color, form, structure and size — as compared with the original parent forms (Sandomirka-Al'bidum and the rye Viatka). Besides, it must be kept in mind that the conditions of their external environment were analogous during their whole ontogeny.

The regularities for obtaining such vegetative hybrids of double coalescence (chimerical plants) have been investigated by the Station and [this information is] made available to us upon request.

3. Dynamic Coalescence Type

In case the shoot of a rye stock is cut rather high, so that the base of its first leaf and the tillering point remain partially in it, and if the scion has also retained these very parts, then a special type of coalescence will occur, if contact of the corresponding parts is ensured at the junction of the graft components.

Coalescence of plants grafted by such a method is stable, but there occurs a double growth — the "lower growth" normal in cereals and the unusual top growth. In plants grafted by such a method, an elevation is observed in the paraffin bond on the soil, since the first leaf of the stock, which was not cut off, grows and pushes upward the scion which had grown onto it. Yet the latter, having its own base in the form of a first leaf and tillering point, grown together on those same parts of the stock, is growing independently at the bottom, but, with respect to the general habits of the hybrid, an upper growth is obtained. As a result of such a type of coalescence, normal development of the graft components is not obtained during the period of ontogeny. The plant as a whole loses normalcy, begins to look poor and fragile — and perishes at the end of 1-2 months, or develops into a plant of the stock type. Sometimes the death of such plants is hastened by the appearance of fast-growing shoots of the stock which form branches on the 8-10th day of life following germination. All energy of development is concentrated here at the expense of the stem on which the scion that has coalesced with it, grows.

4. Type of Coalescence in which the Scion Forms Its Own Root System

Conditions under which the type of coalescence forms have, in part, been outlined above. It occurs in lowered incisions of the stock and the scion, when the scion, having retained a particle of root tissue in addition to the first leaf with the tillering point, is placed in the lowered incision of the stock (overlapping the zone of actual coalescence). This particle of root tissue regenerates into a distinct rootlet sprouting through the neck of the root of the rye stock and developing into a complete root system. The coleoptile of both graft components coalesce well in the absence of coalescence of their first leaves; this complicates the identification of this type of coalescence, as, in certain respects, the latter begins to bear a resemblance to the first type of "actual coalescence" of the components described by us.

Hybrids of these two types of coalescence differ as to the following characteristics:

a) Besides accuracy of incision as to depth, in the first type of "actual coalescence", complete contact was established not only with the coleoptile, but also with the first leaves, including tillering points of the graft components. On the strength of this, common metabolism between the stock and scion is established immediately after the grafting, and on the 4-5th day the first leaf of the scion emerges from its coleoptile. The rootlet of the stock (rye) also grows. [begin p. 40]

b) In the latter type, the component coleoptile alone coalesced, their first leaves with the tillering points did not coalesce and common metabolism was not obtained. Because of this, the first leaf of the scion does not emerge from its coleoptile before 20-22 days, not before its own rootlet has formed. In this type of coalescence, the wheat scion merely utilizes the endosperm of the rye stock, but later it turns to its own root for "wheat" nutrition, since the root system of rye fails to develop. In essence, the given type of coalescence is analogous with transplantation of a wheat embryo onto the endosperm of a rye grain, with the embryo cut out of it. Analogous are also the results obtained, their effect is negligible, for the influence exerted by the stock on the scion is a temporary manifestation in the form of a single endosperm of a rye stock being utilized by a wheat scion.

In vegetative hybrids of rye and wheat derived from "actual coalescence", the stock influence of the scion is not, however, limited to the endosperm of the stock alone, but is reinforced, in addition, by the root nutrients of the stock in the coalescence of the component cells at the incision junction.

5. Type of "Partial" or "Chimerical" Coalescence.

The type of "partial" or "chimerical" coalescence takes place in an elevated cut of the shoots of stock and scion and the subsequent complete contact of their colptiles, and the partial contact of their first leaves including the tillering points. This type of coalescence produces plants basically of the stock, but there is on the first leaf of the latter a part of the functioning leaf of the scion. The leaf of the scion coalesces either firmly (when the vascular conductive systems of both leaves coincide), or infirmly (when this coincidence has not been achieved). In the latter case, the leaf of the scion functions but a month and then dies without falling off of the stock. From components thus coalesced it is graphically apparent that conjunction (joining), not only of the general contours of the first leaves of the components, but also of the vascular conductive systems of the first leaves is a requisite for the normal development of a hybrid after grafting. This aspect complicates, to a large extent, grafting operations on cereals in the given phase of their development, makes them a subject of accurate, qualified work in which experience, slowly gained, will be of great significance.

6. "False" Coalescence Type.

False coalescence between scion and stock takes place when the incision of a shoot of the stock is elevated and the incisions of the scion vary (any way at all). The appearance of this type of coalescence can be explained only by careless handling of the cut-off stock when held between the fingers during grafting. Pressing of the cut-off shoot slightly between the fingers causes displacement of the incision level of its first leaf situated within the coleoptile though poorly attached to the latter. Hence contact between the scion and the stock can be established only in a part of the coleoptiles which normally do not coalesce. The absence of contact between the first leaves of the components causes growth in the first leaf of the stock, while the first leaf of the scion dries up and curls up within its own coleoptile without leaving it. Later, the first leaf of the stock grows into the coleoptile of the scion, penetrates it, and begins to develop into a distinct plant of the stock which has only one coleoptile of the scion grown onto it. Then, due to pressure from below, the curled up first leaf of the scion is thrown from its coleoptile by the developing first leaf of the stock which has grown through the coleoptile of the scion. The end result of such type of coalescence is the development of a stock plant. This type forms rarely and is hard to identify.

All of these six types of coalescence have been well investigated by the Station and their theoretical and practical production has been adapted. Five of them were investigated in 1940-1941, and the sixth type — "double coalescence" — was adapted in 1946-1947.

The valuable practical results obtained are of scientific and of production interest. We are unable to dwell here on the conditions of external environment of the post-grafting period which perform an important role at the critical point in the existance of young hybrid plants. Influence exerted on coalescence, on viability after grafting and on the subsequent development of hybrids, by such factors as light, heat, moist chambers, has been studied by us experimentally.

We shall set forth these problems, together with a literary survey of achievement and of criticism of vegetative hybridization, in a specialized work enhanced with detailed illustrations.

It appears from our work that the six types of coalescence vegetative hybrids of wheat and rye, described and investigated by us, are conditioned entirely by the structural specificity of the stem and the growth of cereal crops.

Absence of the point of apical [verkhushechnoi chasti] growth in the stem and any fullness within it, as it is found in dicotyledonous plants, is responsible for the complexity and the need of great accuracy in grafting operations, including the coordination of its separate elements. Regardless of this fact, a certain share of the success in the performance of grafting operations, even by an experienced worker, is always subject to hypothesis. The very existance of the six types of coalescence, which we have described, and of which only two types produce real vegetative hybrids, bespeaks the justice of the above statement.

CONCLUSIONS

Vegetative hybridization of cereal crops is a potential in deriving new, highly valuable varieties and to produce new forms through "splingering".

The first rye-wheat vegetative hybrid produced by the station in 1940-1941 has become the Station's best variety, surpassing in productivity all varieities in competitive testing in the course of 4 years, and exceeding the productivity of control plants [standard] by 32.2% on the average in 3 years of tests. By decision of the State Commission, it now has been turned over for tests to the State Seléction network of the Iaroslav, Kostroma, Ivanovo and Vladimir Regions.

The hybrid has a leaf with a rye pigment, high winter hardiness, is resistant to sclerosis, develops rapidly after sowing, sprouts early in the spring, and has other economically and biologically valuable properties. In 1948 it was seeded on kolkhozes near the Station on an area of 5.5 ha; in addition, it is being propagated at the Station.

A technological analysis of hybrid grain of the 1947 yield, carried out by the laboratory of grain technology at the Institute of Grain Economy of the Non-Black Soil Belt, has verified its superior properties as to milling and bread-baking; in its wet gluten content, the hybrid exceeded its scion (Diurabl' variety) by 8%, and Sandomirka Iaroslavskaia — best variety in the Iaroslav Region with respect to these properties — by 6%. In dry gluten it surpasses the Diurabl' variety by 2.1% and Sandomirka by 1.5%, in addition to other superior hybrid-grain properties with respect to milling and bread-baking. The Station has produced other vegetative hybrids also: (F_0 and F_1 between Viatka rye and Sandomirka Iaroslavskaia). The conduct of these hybrids, in the area of reorganization of their biological basis and the inheritance of parent properties, is a repetition of the behavior history of our vegetative hybrid Diurbl' x Viatka. For instance, the zero generation referred to produced tall-growing plants, equal in height to rye grown right there for control purposes, with a modified form of the spike. Seed of this generation, having been sown for the year 1949, produced sprouts with violet coleoptiles, resembling the color of rye sprouts, while the sprouts of the scion Sandomirka, as well as the majority of wheat varieties have no such pigment whatsoever.

Our eight-year work of vegetative hybridization of Gramineae enables us to establish the same regularities, in the formation and development of vegetative hybrids between rye and wheat, that were so brilliantly demonstrated by the great transformer of the nature of fruit perennials, I. V. Michurin.

Iaroslavskaia Gosselekstantsiia

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Abstracts].

GOLOVTSEV, L. A. (1948)

Vegetative hybridization of Gramineae.

Agrobiologiia, 1948(1):153-157 [USDA 20 Ag822]

Abstract by R. Adelman

Experiments in Gramineae embryo transplantation were begun at the Ivanovo Selection Station in 1939, but were interrupted due to World War II.

In the spring of 1946 the experiments were renewed with the following varients:

1) the embryo of Ukrainka winter wheat was transplanted onto the endosperm of Liutescence 62 spring wheat;
2) embryo of hybrid Pionerka Koga onto the endosperm of Arnautka Kochina hard spring wheat;
3) embryo of winter rye Tarashchanskaia IV onto the endosperm of the spring wheat Tsezium III.

The grain of the scion was cut with a razor blade crosswise into two equal parts. The smaller part was removed with pincers and the larger part containing the embryo was soaked in cold water from 30-40 hours; later the saturated semi-fluid endosperm was extracted fully from the grain, leaving only the embryo with the grain coat. Then an embryo was cut out of a dry grain of the stock, and the remaining endosperm was put into the grain coat of the scion, so that the incision could be arranged to fit the cyme of the embryo. On the surface the grain coat was tied with thread so as to join it firmly with the inserted stock endosperm.

Following this operation the grafted grains were seeded in boxes in a greenhouse.

Author describes their subsequent development carefully, giving time of year when grains were seeded and when new characteristics appeared. Author stresses the fact that a change in characteristics can be obtained only if embryo transplantation is performed in a vegetating plant. A conservative characteristic such as profusion of awns will not change if the embryo transplantation is carried out in a mature grain. The excess of awns begins to develop at a certain stage of the embryonic process and can be altered only at that particular stage of development by the substitution of unaccustomed conditions.

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KHMELEV, B. I. (1950)

Transplantation of the embryos of Gramineae.

Doklady Akademii Nauk SSSR, 70(5):909-912. February 11, 1950. (In Russian) [USDA 511 P444A]
Vsesoiuznyi Nauchno-Issledovatel'skii Institut Sakharnoi Svekly, Kiev.

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Abstract by R. Adelman

Concomitantly with experiments in vegetative raprochement of wheat and barley, the Institute undertook to improve the method of embryo transplantation. The incentive of the experiments was spurred by two factors — first, because the method of embryo transplantation has already gained widespread use in the country's Selection Stations, and second, because most investigators have been gaining but a low percentage of success.

The author repeats that the fundamentals underlying the method are Lysenko's teachings to the effect that external conditions assimilated by an organism cause a change in its heredity. Author concludes with the assertion that the grafts accomplished according to the improved method (moistening of embryo and endosperm) increase not only the percentage of success, the rate of growth, and the viability of the hybrids, but also the degree of influence exerted by the stock upon the scion. Article includes table showing results.

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KHMELEV, B. I. (1950)

Influence of size and amount of endosperm-stocks upon the growth of vegetative hybrids of Gramineae.

Selektsiia i Semenovodstvo, 17(3):21-25. March, 1950. [USDA 61.9 Se5]

Abstract by R. Adelman

Proceeding from the premise that an appropriate change in the nutrients fed a young plant produces an adequate change in its hereditary properties, the researchers concerned decided to use the embryo transplantation method in their experiments with spring wheat.

The method consisted of the following: the embryo was cut off of the scion kernel with the blade of a safety razor and with due care so as not to injure the cymo, yet to leave on it as little as possible of the endosperm. The separated embryo was pasted with flour paste onto the endosperm stock in dry form on the place where its own embryo had been removed, and then it was planted in sand or in soil.

Concurrently with the work on intraspecific and intrageneric grafting of wheat for the purpose of immediate improvement of regionalized varieties, the experiments worked also on vegetative raprochement of wheat and barley for the purpose of their subsequent crossing aimed at obtaining a more producrive variety of spring wheat. Here the problem was a little different due to the different chemical composition of the barley.

In a second experiment, the embryos and endosperms were moistened before they were grafted, and an effort was made to select large kernels. Article includes a comparative table.

All-Union Scientific-Research Institute for Sugar Beets [Vsesoiuznyi Nauchno-Issledovatel'skii Institute Sakharnoi Svekly]

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KHMELEV, B. I. (1952)

Vegetative raprochement by method of embryo transplantation.

Selektsiia i Semenovodstvo, 19(5):10-15. May 1952. (In Russian)
[Library of Congress SB 13 S4]

Abstract by R. Adelman

In an effort to develop valuable hybrid material, the Ivanovo Experimental Selection Station conducted investigations as to the feasibility of improving cross-pollination action by the method of embryo transplantation. Hard and soft summer wheat served as experimental objects.

They grafted the embryos of one variety of wheat onto the endosperms of another variety of wheat. The vegetative hybrids obtained were crossbred with the variety whose endosperm had been used in the capacity of the stock. The vegetative hybrid was always used as the pistilate plant, while the common plants of the variety used in the capacity of the stock served as staminate material. Control plants were crossbred simultaneously — they were maternal plants regrafted on their own endosperm, or the progeny of such plants (in the investigation of the first generation of vegetative hybrids).

Depending on existing conditions, the actual crossing was accomplished by one of the following methods: 1) conventional artificial pollination, 2) "self-pollination" in large isolators, 3) limited pollination by the wind.

The article has 8 tables showing comparative results.

CONCLUSIONS (in full)

1. Vegetative raprochement by the method of embryo transplantation increases cross-pollination capacity of hard and soft wheats considerable; this increase is observed in straight and in reciprocal graftings.

2. An increase in the percentage of fertilization is observed under various methods of pollination and under sharply different ecological conditions.

3. In one-time graftings the increase in the percentage of of fertilization is observed in the crossing of F_0 and in the crossing of F_1. In the latter case the fertilization percentage is higher.

4. A two-fold grafting raises the percentage of fertilization higher than a one-time grafting.

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KUPERMAN, F. M. (1939)

Grafting technique for Gramineae.

Iarovizatsiia, 1939(5-6):147-150. September/December, 1939. (In Russian) [USDA 20 Ia7]

Abstract by R. Adelman

In early 1939, when the method of embryo transplantation was still young, researchers at the Kabardino-Balkarskaia State Selection Station (In City of Nal'chik) found that transplantation of sprouting embryos was inexpedient, and hence they concentrated on transplantation of embryos in a dry state. They cut off the embryo, together with the cyme of a dry grain and transferred it with a flattened needle onto the endosperm of a grain whose own embryo had been removed. They pasted the embryo to its new endosperm with paste prepared from a pure endosperm of a grain of the same variety on which the transplantation was being performed. They sometimes transplanted two embryos on one endosperm and sometimes one embryo on a double endosperm, and found that transplantation on a double endosperm produced stronger plants than did control specimens. For hybrid components they utilized "Liutescence 062" and "Timopheevi" wheats, barley, and "Sterling" maize.

In the fall of the same year they conducted similar experiments with winter wheats. They took components from "Zemka", "Stravropol'ka", "Sarybugda" and "Timpheevi" wheat; for the study of influence exerted by nutrients of different endosperms, they used endosperms from kernels of barley, couch grass, rice and maize.

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MEDVEDEVA, G. B. and BAZAVLUK, V. Iu. (1953)

An investigation of directs effects of embryo transplantation upon form development in hybrids.

Trudy Instituta Genetiki, no. 20, 1953, pp: 100-105. [USDA 442.9 P44]

Plant Breeding Abstracts, v. 24, no. 3, 1954

Hybrids of the hard wheats Candicans 75/09 and Mutica-Valencia 89 with Kahetinskaia Vetvistaia [Branching Kahetian] gave segregates in respect of grain characters and branching habit. Some F_2 plants bore large and vitreous grain of a quality equal or superior to that of the hard wheat parent. The percentage of plants with good quality grain increased when embryos of the hybrids were transplanted on to the endosperms of the hard wheat parent. This practice, however, reduced the percentage of plants with branching ears. Similar grafts of the hybrid endosperms on Kahetinskaia Vetvistaia increased the number of plants with branching habit, but decreased the number with grain of the hard wheat type.

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NIKITENKO, G. F. (1949)

News in method of vegetative hybridization of Gramineae.

Selektsiia i Semenovodstvo, 16(11):22-29. November 1949. [USDA 61.9 Se5] (Mordovskaia Gosselekstantsiia MASSR).

Abstract by R. Adelman

In an effort to obtain vegetative hybrids of barley that could serve as initial material in developing a highly productive naked-grain variety of barley, the researchers selected the method of embryo transplantation.

For graft components they selected the best varieties of awnless and pronged [furkatnye] barley, including those with naked grain as well as those with coated ones. In addition, they performed repeated grafts of the second seed generation on original forms — Pallidum and Trifurcatum.

They used the following technics. Embryo was cut off of graft components with a safety razor. Incision was made most carefully and close to cyme. In such cases the surface of the embryo incision is a mealy white and the slightly darker spot of its own embryo can barely be seen through it.

The endosperms, relieved of their embryos, were notched on the incision surface with a safety razor in two reciprocally perpendicular direction. The embryos and endosperms were moistened with water (of room temperature) and the transplantation commenced. Embryos were pressed tightly against the surface of the notched and moistened endosperm incision which, puffed up from hydro-action, took on the consistency of paste and thus facilitated the pasting on of the embryo quickly and fully.

To ensure success in: a) compelling the embryo to assimilate unaccustomed nutrients from the stock-endosperm; b) prolonging endosperm action upon embryo; c) increasing the amount of plastic substances assimilated by the embryo from the endosperm-stock in the first stages of its development.

Since the above objectives called for a strengthened reciprocal influence of the graft components, the researchers planted the grafted grain at a greater depth (7-8cm), and increased artifically the amount of plastic matter of the stock.

The conclusions drawn are:

1) that vegetative hybrids can be obtained from barley;
2) that new methods such as "deep planting" are discovered in the process of experimental work;
3) that directed variations can be obtained in the year of grafting;
4) that the work concluded has produced valuable forms of barley hybrids (naked grain, good straw, etc);
5) that new forms bearing the character of new formations raise certain questions of barley taxonomy and phylogeny;
6) that vegetative hybrids constitute good initial material for selection work.

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PISAREV, V. E. and VINOGRADOVA, N. M. (1946)

Intergeneric hybridization in the family Gramineae.

Trudy Zonal'nogo Institută Zernogo Khoziaistva Nechernozemnoi Polosy, 13:124-133. [Sel'khozgiz, Moscow, 1946] [USDA 106 Z72]

Abstract by R. Adelman

In 1941, the authors conducted experiments by hybridizing cultural wheat, barley and rye with species of Elymus.

The work, commissioned by Tsitsin*, was to be conducted for the purpose

*Editor of book.

of finding methods that would simplify distant hybridization.

Preliminary experiments to hybridize species of Elymus with wheat and barley proved that the success of such crossing was frequently thwarted by the difficulties involved in developing an embryo that is already in a state of germination.

Other failures encountered by the authors and other researchhers, including Quincke and Thompson, prompted them [the authors] to look for a method of raprochement by biochemical characteristics of genera designated for crossing.

The Michurin method of preliminary vegetative rapprochment was not technically developed for cereal grafting, and their experiments with this practice also ended in failure.

Hence, they decided to try reciprocal transplantation of embryos of one species or genera onto the endosperm of another. Their motive for these experiments were the recent investigations conducted by Schander, Kholodnyi and others, on the role of phytohormones placed in endosperms of cereals, and of their influence on the development of the embryo as well as on the grown plant.

They worked with soft wheat and rye which included ecotypes producing a high percentage of hybrid grain, as well as some that do not cross at all.

The article includes a seemingly adequate account of the method employed and a description of the results.

Cytologically only one hybrid plant (summer wheat VEP_2 X E. arenarius) had been investigated at the writing of the present article. Taking into consideration that the maternal form of Tr. vulgare had the chromosome $2_N = 42$, and Elymus arenarius $2_N = 56$, the hybrid was found to have $2_N = 49$ (Poddubnaia -Arnoldi).

The authors claim that they were the first to obtain normal, mature, first generation plants from a cross between soft wheat and E. arenarius in the history of selection.

There is further comparative data on the yield of hybrids and control plants.

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Trans. 521
[Collection of
Abstracts]

PISSAREV, V. E. and N. M. VINOGRADOVA (1946)

Intergeneric hybridization in the grass family.

Trudy Zonal'nogo Instituta Zernogo Khoziaistva Nechernozemnoi Polosy SSSR, vol. 13, 1946, pp: 124-133. [USDA 106 Z72]

Biological Abstracts, v. 23, 1949 [G. L. Stebbins, Jr., Abstractor]

The following method was used to facilitate hybridization between distinctly related spp. of grasses of the tribe Hordeae. Using a safety razor blade, the embryo and scutellum, with as thin a layer of endosperm as possible, were cut away from dry seeds of one species, then transferred to seeds of another species, from which the embryo had been cut away, and attached with the aid of a paste made from the flour of seeds belonging to the species which served as the "stock" of the "graft". Plants grown from such "grafted embryos appeared normal except for the character of their grains. Plants of spring wheat var. Lutescens 062 grown from embryos grafted onto endosperm of spring rye, had seeds of a dull gray color, less vitreous, more angular, and more deeply furrowed than seeds of control plants of Lutescens 062 raised under the same conditions. Chemical analysis showed higher content of N, protein, sugar, and ask, and a lower content of starch than the controls. Gluten isolated from them was dark brown, as in rye, due to different content of tyrosin and a different activity of tyrosinase, and they contained the carbohydrate trifrucatosan $C_{18}H_{30}O_{15}$, found normally in rye but not in wheat. These changes are explained by the presence of hormones derived from the rye endosperm. Embryos from grafted plants were again grafted to the endosperm of rye, and the resulting plants were pollinated with the same var., yielding 25% of seeds as compared to 4% in the controls. Plants of Lutescens 062 grafted onto var. Aurora of rye gave 19.8% of seeds in crossing, as compared to 2.8% in the controls. Spring wheat 10H68 grown from embryos grafted to the endosperm of Elymus arenarius gave 5.2% of hybrid seeds with that species as compared to 1.9% for the controls. Spring wheat from Finland grafted to E. aralensis gave 15% of seed when crossed to that species, while controls gave none. Spring wheat VIR22879 twice grafted onto E. giganteus gave 6.2% seed when crossed to that species; once grafted plants gave 2.3%. Embryos of Elymus grafted onto wheat endosperm gave seedlings in 4-5 days as compared to 14-15 days for the controls. Pollination of wheat with pollen from Elymus grafted onto wheat endosperm gave 17% hybrid grains, the controls 0.4%. Most of these grains had abortive embryos and failed to germinate, but one strong hybrid of Finland spring wheat x E. arenarius and one of spring wheat VEP2 x E. arenarius grew to maturity. In vegetative characters they resembled Elymus, but their spikes were intermediate. They had 49 chromosomes, the expected number.

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PISSAREV, V. E. and VINOGRADOVA, N. M. (1944)

Hybrids between wheat and Elymus.

Comptes Rendus (Doklady) de l'Academie des Sciences de l'URSS, vol. 45, no. 3, Oct. 30, 1944, pp: 129-132. [USDA 511 P444]

Plant Breeding Abstracts, v. 15, 1945

A method of grafting the embryo of one component of an intergeneric cross on the endosperm of the other has been applied in hybridization experiments with wheat, barley, rye and Elymus. Wheat plants of the variety Lutescens 62 produced by growth on the endosperm of spring rye were morphologically similar to the controls. The grain, however, differed from that of the controls by its dull coloration and less vitreous appearance. The chemical content of the grain of the grafted wheat approached that of the spring rye. An increased percentage of grain was obtained from crosses between grafted Lutescens 62 and the rye; growth hormones in the rye endosperm are believed to be the chief factor responsible for its increase. In hybridization experiments involving wheat and Elymus the best results were obtained in those cases where both male and female plants of one component had been grafted on the endosperm of the other. The hybrid seed gave a very low percentage of germination on account of the abnormal development of the embryos. Vigorous plants, described as hybrids, have however been obtained. These possess leaves resembling those of Elymus and spikes of mixed type.

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PLOTNIKOV, I. G. (1939)

Grafting technique for Gramineae (a preliminary report).

Iarovizatsiia, 1939(3):63-65. May/June 1939. (In Russian) [USDA 20 Ia7]

Editor's comments only:

Plotnikov's article is interesting as a description of the first attempts to graft Gramineae for vegetative hybridization. It must be noted, however, that the technique used cannot as yet be considered as fully developed. Plotnikov's methods have essential shortcomings. In the first method (transplantation of embryo) the action of the stock may be insignificant, since the scion feeds on its own root. In the second method (transplantation of shoot) the shoot may produce its own root and also feed on its own root. The third method (grafting in the surface node) is more promising, but here the work was accomplished with adult plants and consequently, the influence of the stock can assert itself in but a small degree.

Translator's note: It is interesting that editor questioned author's methods in 1939.

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RIURIKOV, N. A. (1948)

Summer wheat "Vegetative hybrid No. 1".

Selektsiia i Semenovodstvo, 15(7):36-39. July 1948. (In Russian)
[USDA 61.9 Se5]

Abstract by R. Adelman

Preliminary work was begun in 1939. Seed were soaked in water and just as soon as, the embryos began to sprout — to peck through — they were transplanted together with the cyme onto the kernel of another wheat variety. With the operation completed the grain were put in Petri dishes under glass, but in a few days the grafts perished.

After an interruption, the work was renewed in 1944. In the new experiment the grafted seed were planted in an open box in very moist soil and covered with soil of normal moisture. When the third leaf appeared, the seed were planted in soil in the open.

The article contains 4 tables indicating positive and negative characteristics of Hybrid No. 1 and analyzing its yield.

In conclusion, the author states that the conduct and all indicators of Hybrid No. 1 confirm the theoretical principles of Soviet agrobiological science, and that cereal crops with positive economic characteristics can be obtained by means of form modification.

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SEKUM, P. F. (1949)

Vegetative hybrids among cereals.

Selektsiia i Semenovodstvo, 16(2):22-27. February 1949. (In Russian)
[USDA 61.9 Se5]
(Moskovskaia Gosseloktstantsiia)

Abstract by R. Adelman

Author indulges to some extent in pro Michurin-Lysenko and anti Mendel-Morgan propaganda. His experiments are conducted along the line of Khmelov's. The embryo of one form of wheat was grafted onto the endosperm of another form. The embryo was pasted onto the alien endosperm with paste made of flour from the wheat variety of the stock endosperm. To prevent the formation of mold over the grafted area while the grafts were germinating, the experimenters poured collodium over it. Article includes 5 comparative tables showing morphological characteristics of original forms and those of hybrids, of growth intensity and other variations.

Author cites other experimenters — Brusnetsov, V. F. Illarionov, Pisarov and Vinogradova, etc. — whose experiments have been successful.

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VATULIA, E. E. and KUCHUMOV, P. V. (1954)

New forms of wheat obtained by the method of vegetative hybridization.

Agrobiologiia, 1954(3):68-72. July/August 1954 (In Russian)
[USDA 20 Ag822]

Abstract by R. Adelman

Transplantation of wheat embryos onto endosperms of rice in intergeneric grafting. Authors declare that this method is not a new one and they cite N. P. Aleev, "Experiments in Changing the Nature of Wheat by the Method of Vegetative Hybridization", Agrobiologiia, 1948(4):48-56. July/August 1948.

Authors found that success depended on coordination between the accessibility of nutrients of the rice endosperm and the ability of the wheat embryo to assimilate them.

Authors experimented on rice grain with sprouts 1 to 10 mm long; they softened the kernels by soaking them from 4 to 6 hours, since this process fascilitated the removal of the embryo. After cutting off the wheat embryo with a razor blade, they placed it on the area of the incision made on the rice endosperm when its own embryo was removed. Then the grafted kernels were planted in vegetative containers. Of the 50 grains planted 38 grew satisfactorily.

The variations discovered in the plants of the first generation convinced the authors that real vegetative hybrids can be obtained by transplanting wheat embryos on rice endosperms. The best and most productive plants were those of the fourth generation.

The high productivity of wheat/rice vegetative hybrids indicates that they may be of selection value.

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[The following four articles are included for general interest, although they do not deal especially with cereal vegetative hybridization].

BORKOVSKAIA, V. A. (1941)

Grafting hybrids and chimeras.

Iarovizatsiia, 1(34):78-83. January/February 1941. (In Russian) [USDA 20 Ia7]

Conclusions.: [Translated by R. Adelman]

1. In grafting, the most rapid and sharpest changes take place in the young cells which have formed in the area where the scion and the stock grow together, since here their selectivity with regard to the usual conditions of life can be realized least of all.

2. Old tissues of the scion and the stock which have formed on their own roots change considerably less and more slowly. But the number of accumulated changes in a young shoot, develop from such tissue, can be la rger in "incision" [srez] grafting than in grafting performed by the usual method, since the removal of all assimilators of the scion makes a shoot, which is beginning to regenerate, dependant on the stock.

3. If sharp changes are to be obtained rapidly in a plant exposed to the influence of the stock, then the method indicated for developing shoots in the area where the scion and the stock grow together can be considered, at the given stage, as the more effective one.

4. Changed plants obtained by grafting Solanum nigrum onto a "Shtofert" tomato "by incision" [so srezom] are hybrids. Their hybrid nature has been proved by the intermediate character of all characteristics combing the generic peculiarities of the stock and the scion, and also by the sterility in self-pollination inherent in the first generation of generically distant hybrids.

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MEDINETS, V. D. (1951)

Properties of maternal organism in progeny of hybrids.

Selektsiia i Semenovodstvo, 18(7):3-12. July 1951. (In Russian) [USDA 61.9 Se5]

Abstract by R. Adelman

Article devoted to reciprocal hybrids of various crops, vegetables and animals, includes also observations on reciprocal hybrids of cereals. [p. 7-10]

In examining reciprocal influences that takes place between the embryo and the endosperm, the author rejects the idea of "plasmatic heredity". He subscribes to the theory that the organism develops new properties and characteristics in accordance with the varying demands which it exacts of its environment during the different stages of its growth. Considerable space is given to the influence of the maternal organism and it is asserted that the properties of the maternal organisms are more pronounced in cases of free fertilization than in cases of artificial fertilization [pollination].

In conclusion the author justifies the opinion that the reproductive process — process of fertilization and development of embryo — is an entity [or union] of two forms of hybridization — the sexual and the vegetative.

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SEMENENKO, G. I. (1952)

Change in nucleoprotein content in plants upon vegetative hybridization.

Biokhimiia 17(6):655,659. November-December, 1952. (In Russian)
USDA Trans 511 [USDA 385 B523]

Conclusions only, by R. Adelman

[Experiments were conducted with tomatoes of the "Margleb" variety; eggplant of the "Delikates" variety; and the seed offspring obtained from tomato/eggplant grafts].

In vegetative hybridization, substantial quantitative changes occur in the phosphorus content of mucleoproteins in the young growing organs and tissues of grafts and hybrid progeny.

In grafting tomatoes onto eggplant and vice versa, the change in the phosphorus content in nucleoproteins in the leaves of the scion is inclined to favor the stock, and in the case of repeated grafting it increases.

In the seed progeny of vegetative hybrids, concurrently with a vigorous manifestation of heterosis, an increased nucleoprotein content is observed in the leaves, blossoms, tips of shoots and in the young seedlings of hybrid plants as compared with the original [plant] forms.

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Trans. 521
[Collection of
Abstracts].

GLUSHCHENKO, I. E. (1950)

Hybridization of Plants by Grafting.

Uspekhi Sovremennoi Biologii 30(1):15-48, July/August 1950. (In Russian)
[USDA Trans. 512] [USDA 442.8 Er3]

Conclusion, By: R. Adelman

1. Vegetative hybrids show that simple heredity characteristics in vegetative reproduction can, as Timiriazev asserted, turn into complex heredity characteristics in sexual reproduction.

2. Experiments in vegetative hybridization show an inconsistency in the chromosome theory of heredity the principle of which is cell from cell, nucleus from nucleus, chromosome from chromosome, gene from gene.

Vegetative hybrids convince one that somatic cells undergoing physiological changes will, in the end, produce altered sexual cells. There is no immortal embryonic course. There is a course of qualitative transformation of soma capable of forming sexual cells at a certain stage.

3. There is a similarity, a parallelism, between sexual and vegetative hybridization. It is a fact that the second method, as well as the first, will transmit any characteristics, any property from one component to the other. These properties become fixed in the seed generations.

4. Side by side with parallelism there exist differences. A typical feature of vegetative hybrids is the different type of fission of characteristics. Not only the plants vary in their basic characteristics, but a sharply pronounced differentiation occurs [proxodit] within the organism. In vegetative hybrids the mixed type of heredity is basically intrinsic.

5. A characteristic of graft hybrids is the different form of manifestation of property dominance. Plants with recessive characteristics often produce offspring with dominant characteristics.

6. Crossbreeding carried out between vegetative hybrids and parents with graft components and recessive characteristics demonstrate graphically that dominant characteristics may appear in the offspring. This indicates that separate characteristics in hybrids are in a latent state and, under appropriate conditions, develop subsequently in the offspring.

7. On the change in external morphological characteristics, a profound reorganization of order takes place in hybrids, the character of cell structure changes in particular, plastids of various types appear in the cells.

8. Biochemical investigations show that the majority of quantitative and qualitative indicators of the second graft component — the mentor — appear in the seed progeny.

9. Frequently the absence of visible changes observed in the year of grafting does not denote an absence of specific qualitative changes in the generative cells of the plant. Hence it follows that the progeny of grafted plants must always be investigated, even though no phenomenon of variation in characteristics had been observed in the year of grafting.

10. It would be most primitive to think that as a result of grafting one always has to look for grafts of the stock in the offspring of the scion, or vica versa, to discover properties, characteristics of the scion in the offspring of fruit of the stock. Living [substance] constitute a process of development, and every biological process does not know of straight, direct changes. They are realized only in a long chain of transformations.

Besides the phenomena of straight hybridism (presence of the characteristics of both parent components in the offspring), vegetative hybrids include also the phenomena of new formations, i.e. the creation of new characteristics frequently not inherent in either one of the graft components. A pre-requisite for this is extreme instability, inconstancy of form, frequently observed in intraspecific and, most often, in distant [Intergeneric] graftings.

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Trans. A-522
(In part)
By:
R. Adelman

Golovtsov, L. A.

Grafting Cereal Plants.

Agrobiologiia, 1952(5):80-90.
September/October 1952. 20 Ag822
(In Russian)

GRAFTING CEREAL PLANTS

The author believes that the Michurin method of vegetative hybridization would aid in the production of valuable varieties of grain crops. He states, however, that this method is not as yet being used in cereal selection because the hollow stalk of these plants presents a problem different from that of woody plants.

To investigate this problem, the author and his colleagues were guided by the hypothesis, that the plant changes under the influence of external evironment.

They based their experiments on two principles: first, modification of organic nutrients during embryonic and postembryonic development of plant by embryo transplantation, and second, coalescing embryo particles of various species of cereals.

In their seven-year investigations they developed three methods of vegetative hybridization:

1) transplantation of embryo on a mature grain;
2) transplantation of an embryo particle;
3) method of the double mentor.

In the last five years investigators experimented with 92 different combinations and carried out over 50 thousand grafts, but they describe only the more characteristic samples.

(1) Transplantation of embryo on a mature grain.

Frequently the embryo is cut off with a razor blade and is pasted onto endosperm with some adhesive substance without providing for contact between scion and stock or for conditions for feeding of embryo on the endosperm. Such a graft deteriorates under influence of moisture and soon perishes.

Trans. 522
(In part)
By:
R. Adelman

The author's method provides for cutting a dry grain with a razor blade on the tufted side and for soaking it in water at room temperature for 24-30 hours, until the endosperm is in a semiliquid state, then it is removed from the grain coat leaving only the embryo and the empty coat. Then they take a dry grain on whose endosperm the graft is to be performed, cut off the embryo and put the dry endosperm under the coat of the scion (embryo) with the incision adjoining the cyme of the grafted embryo. They use no adhesive substances. The place of junction of the embryo and endosperm is covered tightly with the grain coat (of the scion). This close relationship between embryo and endosperm is not disturbed until the endosperm is fully utilized. The binding link is the grain coat itself, and not an adhesive substance; coalescence reaches 100%. Seeding can be carried out in a vessel containing moist soil. At optimal temperature, sprouts appear in 5-8 days.

There follows a description of the development of combinations of different varieties, of the influence exerted by the endosperm on the process of vernalization of winter wheat, and of the modification of varietal characteristics under the influence of grafting on endosperms.

(2) Method of transplanting particle of embryo (Mentor).

Experimenters use dry grain of both graft components and on the grain of one of these, they partially cut off, with a razor blade, the coat surrounding the embryo. Then they cut out of the naked embryo laterally, a piece about 0.3-0.5 mm thick on the demarcation line between the initial pedicle and rootlet. The depth of the incision is extended to the very endosperm; pedicle and rootlet of the embryo are completely separated.

Following the above, a particle of the embryo of living tissue (the mentor) is cut from the dry grain of the other graft component in the form of a wedge-shaped blade and is placed in the incision made in the first grain. The grain coat is placed over the embryo and its incision is slightly flooded with paraffin. The embryo operated on represents a complex formation in which the rootlet and pedicle belong to a plant of one variety, and the meristem tissue connecting them — to a plant of another variety.

The grafts are seeded in boxes with moist soil covered with a 3-4 centimeter layer of well rinsed and calcined sand. The grafted grains are in the layer of sand close to the surface of the soil, so that the germinating rootlets enter the soil directly.

At optimal temperature and moisture, the embryo begins to grow; the mentor particle begins to germinate at the same time and grows into the embryo. Coalescence occurs in 5-6 days. Exact determination of the spot in the embryo on which the mentor particle is to be transplanted is of utmost importance. A slight deviation may result in failure of the transplantation.

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(In part)
By:
R. Adelman

(3) Method of double mentor.

Vegetative hybridization of cereals by the method of the Double Mentor represents the combination of the two methods described — transplantation of embryo onto an endosperm and insertion of a particle of the stock embryo into it [first embryo].

Here, on one hand, the endosperm serves as a mentor, and on the other hand, the embryo particle serves as a mentor. The grafting technics do not change, but the experimenters perform two operations on one plant: first, they graft an embryo on the endosperm, and then they insert an embryo particle of that form on the endosperm of which the grafting is performed.

By the double mentor method, they accomplished grafts between winter wheat and maize, with Khar'kovskaia 23 maize serving as mentor. They soaked the wheat grain in water of room temperature, extracted the softened endosperm from the grain after 30 hours of soaking, and inserted the dry maize endosperm in its place. Since the grain of maize is much larger than the grain of wheat, and is differently shaped, the maize endosperm was first rounded off and then inserted under the grain coat of wheat. Having completed the first operation, they began the second one. Using the method described earlier, they inserted the blade from the maize embryo into the sprouting wheat embryo. By this method they made one hundred grafts, using three control variants.

CONCLUSIONS

1. Vegetative hybridization can be realized by embryo transplantation and by coalescing embryo particles of plants of different varieties, species and even genera and families.

2. By grafting an embryo onto an endosperm and, concomitantly, inserting into it [embryo] mentor particles, it is possible to produce in a plant deep hereditary variation.

Trans. A-523
(In full)
By:
R. Adelman

Kozarenko, M.

Some results from Vegetative hybridization of cereals.

Zemledelie, 1954(2):114-115. (1954)
20 Z44

(In Russian)

SOME RESULTS FROM VEGETATIVE HYBRIDIZATION OF CEREALS

In the Trunov Region, situated in the arid steppe of Stavropol' Territory, spring wheat is often subject to incomplete respiration [zapal] and, therefore, produces a low grain yield.

Proceeding from the principles of the agrobiological science of Michurin, I set myself the task of improving the properties of grain in winter wheat and the developing of a drought-resistant variety of spring wheat equal to winter wheat in grain yield, by means of vegetative hybridization.

For this purpose, I selected in 1948, the following parent pairs: "Melianopus 69" x "Boroshilovskaia"; "Voroshilovskaia" x "Melianopus 69"; "Kooperatorka" x "Melianopus 69"; "Melianopus 69" x "Kooperatorka"; "Melianopus 69" x "Coach grass-wheat hybrid", and a series of others.

We accomplished vegetative hybridization by joining the endosperms of two grains with germinating rootlets and sprouting pedicals of equal size.

We soaked the seed in water, making a point of first soaking those seeds that had been sprouting for a longer period. We cut the sprouted grain with a razor blade across the embryo. Thus we obtained two halves of a grain: on one-half the rootlet, and on the other pedicel; we left more of the endosperm on the half which we selected as scion or stock. Then, we joined the halves of grain with the rootlet (stock) and those with the pedicel (scion) together, and planted them immediately in moist soil at a 3-5 cm depth. Watering was carried out before a shoot appeared above the soil surface. Further care was the same as that given to grain crops, seeded under field conditions. By this method of growing together, coalescence achieved was 80-90%.

In cases where spring wheat served as the stock and winter wheat as the scion, all plants tillered well toward winter; overwintered completely, plants developed better and ripened a few days earlier than their parent forms.

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Trans. 523
(In full)
By:
R. Adelman

Whenever winter wheat was used as stock and spring wheat as scion, the plants branched out strongly in the fall, but by the time spring came there were left only separate specimens, and most of the plants that survived had the characteristics of vernality.

It must be noted that the characteristics which appeared in the first generation were retained in all ensuing generations. Of a series of hybrids which I obtained, only four vegetative hybrids of winter wheat and three of spring wheat presented considerable interest. These hybrids have a number of advantages over the regionalized wheat varieties in the Trunov Region.

The root system of vegetative hybrids is developed considerably better than that in the "Voroshilovskaia" and "Odesskaia 3" varieties seeded alongside of the hybrids. Besides, the 1952 crop of the vegetative hybrids of winter wheat (No. 1, 3, 4, 5) sown for four years without being treated [with fungicides] were not infected by loose smut or hard smut, while the varieties of "Voroshilovskaia" and Odesskaia 3" were affected by them.

According to morphological characteristics and grain properties, the vegetative hybrids inherited the characteristics of the scion as well as those of the stock. Thus, for instance, the glassiness of the grain of vegetative hybrids of winter wheat is considerably higher than that of the winter wheat varieties of "Voroshilovskaia" and "Kooperatorka", but less than that of the spring wheat variety "Melianopus 69".

Vegetative hybrids surpass the regionalized varieties of "Voroshilovskaia" and "Odesskaia 3" in the yield of grain also, calculating in centners of 8-9 per ha.

Table 1.

Variety	Yield by years (in c/ha)	
	1951	1952
Voroshilovskaia	9.7	16.0
Adesskaia 3	---	19.0
Vegetative hybrid No. 1	18.0	19.9
" " No. 3	18.7	22.4
" " No. 4	14.3	22.6
" " No. 5	15.0	25.5

[Fig.] Root system of vegetative hybrid No. 3 (right) and of winter wheat variety Voroshilovskaia (left).

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(In full)
By:
R. Adelman

In the fall of 1952, the four forms of vegetative hybrids obtained were seeded on lots of 0.5 ha each. The regionalized variety "Odesskaia 3", was seeded on a similar lot in control capacity.

Hybrid No. 1 yielded 14 centners, No. 3 — 16 c., No. 4 — 14.5 c.; while the yield of the "Odesskaia 3" variety came to 12 centners per ha. In the fall of 1953 the vegetative hybrids were seeded on a 15 ha lot for the purpose of utilizing them as initial material in developing new varieties, since they have the tendency to shatter [in the sense of segregation] strongly during the first three years after grafting.

To improve the hybrids obtained in 1949, we carried out selection of plants annually. In 1953 we derived from each hybrid two more varieties which we seeded on separate test lots. Thus, I obtained six varieties with distinguishing morphological characteristics.

In the Stavropol' Territory, spring wheat which produces a low yield is being replaced by gray cereals.

In connection with this I tackled the task of developing a variety of spring wheat by vegetative hybridization that would not only be as good as gray cereals, but just as good as winter crops.

For this purpose I selected in 1949, the following parent pairs for vegetative hybridization.

I selected the "Dzhugara" variety of sorghum for the stock, and for the scion — the spring wheat variety of "Palestinka" which yields up to 25-30 centners of grain per ha in the damp regions of the Stavropol' Territory. The vegetative hybrid of spring wheat possessed the characteristics of both parents. It had a large spike, a stem as hard as that in sorghum, completely filled within with parenchyma and twice as thick as a wheat stem. The root system was also considerably more vigorous than that in ordinary wheat and, in addition, aerial roots appeared on many plants in the form of a supplementary tier. The grain resembled that of spring wheat in shape and color, but was considerably larger. In the absence of rain in the spring and early summer of 1950, the hybrid of spring wheat produced normal grain, while spring wheat developed no spikes whatever that year. We select annually the best plants from the young crop of the hybrid of spring wheat.

In 1952, this hybrid reached the height of 1.5 - 1.6 m.

The absolute weight of a grain of the 1951 and 1952 yield was 59 gr., the weight of grain obtained from a single spike — 2.5 gr. In 1952, spike

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(In full)
By:
R. Adelman

formation and maturing of grain was noted in the spring wheat hybrid 10-12 days earlier than in spring wheat of the "Melianopus 69" variety.

In the second year of seeding, the plants of the vegetative hybrid of spring wheat yielded shatter-derivatives and produced fundamentally three varieties distinct as to color of spike, number of awns and fullness of grain. Heterosis of the vegetative mass of plants appeared in a higher degree from year to year. In 1953, this hybrid of spring wheat was seeded on a lot of 120 square m, and it conducted itself the same as in the preceding years.

Judging this hybrid by its conduct, it can be expected that it will prove fully adequate for cultivation of spring wheat in arid regions.

Trans. A-524
(In full)
By:
R. Adelman

Ustinov, A. A.

Novoe v Izuchenii Gallovoi Nematody -
Heterodera marioni (Cornu. 1879) Goodey

[New aspects in the Study of the Root-knot
Nematode - Heterodera marioni (Cornu, 1879) Goodey]

Trudy Zoologicheskogo Instituta, Izdatel'stvo Akademii
Nauk SSSR, vol. 9, no. 2, 1951, pp: 405-446. 410.9 L543

(Biologicheskii Institut Khar'kovskogo Gosudarstvennogo
Universiteta)

The root-knot nematode belongs to the most important parasites of agricultural plants and represents a widely distributed form. Its global distribution is conditioned by purely ecological factors: the nematode now has invaded every area where conditions are favorable for it. The thermophilic capacity of the root-knot nematode indicates that its place of origin was in a very warm zone, but more in a subtropic than tropical one, since it survives winter colds easily and is found in the ground in White Russia and near Moscow, while tropical organisms are usually very susceptible to low temperatures. In colder areas it is found mostly in greenhouses. The absence of anabiotic capacity in the larva of the root-knot nematode indicates a probability that its source was a moderately humid place, without sharp fluctuation in soil moisture.

There is no available material that would aid in establishing the root-knot nematode's place of origin with some exactness. The first mention of its prevalence was made in 1855 when the nematode was found in a greenhouse in England, but almost simultaneously (1857), it was identified in Florida, where it already had been recognized as a dangerous parasite of agricultural plants, and in 1885 the nematode was found in Java on sugarcane — an old world plant. Its occurrence on wild flora also fails to indicate the indigenity of the root-knot nematode. It possesses a very effective, although passive, method for spreading and is very common in uncultivated soil.

Reports of occurrence of the root-knot nematode in virgin soil have been received from America and Africa, and the author [of present article] has found it in Ukraine in the Donets river area in meadows and pine forests where the soil has never been tilled. The list of hosts of the root-knot nematode includes plants from every part of the world.

Morphology and Development

A more detailed work on the morphology of the root-knot nematode is that of Nagakura (1930); it contains a detailed description of the male and the mature female, the other stages of development, however, are treated poorly. Brief descriptions of the nematode can be found in old monographs: Mueller (1884), Stone and Smith (1898) and Bessey (1911). The illustrations of Stone and Smith were used by I. N. Filip'ev in his abstract on nematodes (Filip'ev, 1934) and in "Handbook on Zoology" (1937). Like those of other authors, these illustrations are extremely simplified and schematic. The embryonic development of the root-knot nematode had not been investigated; the postembryonic development had been interpreted incorrectly until recently, and its clarification has begun only since the appearance of the work of Christie and Cobb (1941).

The root-knot nematode is a heterotropic [geterotopnyi] parasite. The larva which leaves the egg lives for some time in the soil, even though it does not develop there — this is the preparasitic to invasion larva capable of penetrating into the root of a plant. Within the root the larva becomes an internal tissue parasite of the plant and loses its motility. In males motility is restored after they have accomplished metamorphosis, while individuals which are transformed into females remain immotile to the end of their lives. The function of the organism as a while changes during ontogeny of the root-knot nematode: the basic function of preparasitic larve is to find and to invade a host, that of parasitic larva — intensive feeding and growth, and the function of adult males and females — propagation. Naturally, the structure of the different phases depends on their functional characteristics.

Fig. 1. - Map of global distribution of root-knot nematode compiled from available data.

Embryonic and Post-Embryonic Development of the Root-Knot Nematode.

Sexual Cells. The eggs of the root-knot nematode usually are kidney-shaped, slightly concave on one side. The dimensions of eggs fluctuate even in those taken from one ovary [ooteka], consequently laid by one female for a short period of time. The average dimensions of eggs were 92 x 40 unit* (all dimensions given are as per author's measurements). The eggs are supplied with two membranes: external and internal. The first is isolated [vydeliaetsia] by the sexual organs of the female and is a smooth homogenous shell, about 1 unit* thick; the internal or yolk membrane is isolated by the ovicell itself and represents a very thin film. The ovicell contains a large cyst nucleus, and in its protoplasm are found many yolk orbits of a yellow-brown coloring. Eggs are laid by the female in the ovary before they begin to granulate or in the very first stages of granulation. Only on a visible depression of the females do the eggs pass through embryonic development within the sex tubes, since the process of hatching eggs is difficult in these ffemales. Spermatozoons represent spherical cells 7-8 units*in diameter.

Fig. 2 - Eggs of the root-knot nematode in different stages of embryonic development. Invasion larva is visible in last phase, lying in egg under cover of skin of the larva of the first phase; from the right - invasion larva upon leaving egg.

* micron

DEVELOPMENT. At first, granulation of the eggs of the root-knot nematode is uniform; root-knot nematodes show no noticeable difference in the size of the first two blastomeres (described in the case of other nematodes). The cleavage of both blastomeres occurs simultaneously, so that a four cell phase forms immediately. Further, some cells granulate more rapidly, others more slowly, and in the phase of 10 or more blastomeres, it is possible to distinguish the larger and darker cells of the endoderm from the lighter and smaller of the ectoderm. Further, the difference between these embryonic layers increases still more. As the embryo lengthens, there occurs clearly at the anterior part of its body, a separation of the light section composed of ectodermal cells — Stomadeum, from which the digestive tract develops. Further elongation leads to the formation of a worm-shaped embryo (fig. 2), coiled several times within the egg. The final formation of the larva constitutes the longest stage of embryonic development. The invasion larva which has developed and assumed form, molts and then crawl from the egg through the opening which it has made at one of its narrow ends. In contrast to description pertaining to the best nematode, no trophic stimulants are needed for the exit of larvae: Larvae effect their exit also in perfectly pure water. Eggs incapable of surviving are found very rarely, usually not more than 1-3% of their total number in the ovary.

POST EMBRYONIC DEVELOPMENT. Much confusion has been observed in the designation and interpretation of the developmental stages of larvae of the root-knot nematode, [Begin p. 408] hence it is necessary to dwell on this question in greater detail. To begin with, there is no unanimous opinion as to what stage of development invasion larva constitutes when it leaves the egg. It is usually referred to as the first, but I. N. Filip'ev calls it the second, because he believes that the larva, which molts within the egg, constitutes the first stage. Having penetrated the root and turned to parasitism, the invasion larvae change markedly, but they do not molt and still constitute the second stage, if the larva within the egg is considered as the first stage. This is the only prolonged phase during which the larva subsists and feeds. Nonetheless, the changes which larvae undergo in their transition to a parasitic mode of life are so great, that within the root it is looked upon as the ensuing phase developed from invasion larvae by means of molting, and sometimes, even as two larval phases.

Having reached full development and taken on the shape typical for the root-knot nematode, with a pintail [ship] at the end of its body, the larva separates from the old cuticle, which constitutes its second molting, if the molting within the egg is also taken into consideration. The larva lying within the old skin will constitute the third stage; it molts anew during transition to the fourth stage which, under the cover of two skins, molts for the last time and is transformed into an adult form. To illustrate the facts stated above, we will present them in the form of a table showing how different authors have designated the atages of development of the root-knot nematode.

Table 1.

Stages of development of the root-knot nematode as presented by different authors

Actual Stages of development of the root-knot nematode	Designation of these stages by Filip'ev (1934) "Handbook on Zoology" (1937)	Designation by other native authors (Ustinov, 1939, Kobakhidze, 1941, Brodskii and Zemlianskaia 1946	Designation by Nagakura (1930) and Goodey (1933)
1. Larva in egg prior to its molting for invasion	First stage	Considered as embryonic stage of development	------
2. Invasion (pre-parasitic) larva	Second stage	First stage	First stage
3. Same larva, but in state of parasitism (parasitic larva)	Third stage	Second stage	Second Stage
4. Same, at end of its development: strongly expanded and with a pin-tail	Fourth stage	Third stage	Second stage, the final
5. Two moltings within skin of larva with tail* (third and fourth larval stages).	not noted	Not noted	Third stage (only one molting noted)

*See errata at end of book

[Begin p. 409]

COMPARATIVE OUTLINE OF STRUCTURE OF ROOT-KNOT NEMATODE AT DIFFERENT STAGES OF ITS DEVELOPMENT

BODY FORM. The structure of the root-knot nematode changes strongly in the process of ontogenetic development. Preparasitic larva escapes the modifying influence of parasitism and retains the structural characteristics typical of the group. Its body is cylindrically elongated, the anterior end is blunt, the posterior end narrows down gradually and, at the very end, forms a thin conic, rounded tail. The transition to parasitism causes a rapid modification of body form. Thanks to the strong expansion of the intestines, the body of parasitic larva grows even more in width (fig.3). Considerable thickening occurs only in that part of it where the intestines rest, while the tail neither thickens nor grows bigger, but turns into a tenon [ship] at the posterior end of the strongly expanded body. The growth of larvae in length during their transition to paratism is negligible. The bodies of young females are bottle-shaped. The posterior part is an elongated oval, the neck is slightly set off from the body. Females in the state of puberty are pear-shaped; the anterior part of their body is drawn out onto the neck, the posterior — oval or spheric, widely rounded. The body of the male is elongated.

Fig. 3. - Second larval phase of the root-knot nematode after transition to parasitism. Initial phase of parasitic larva; body is expanded; bulbus [bul'bus] has increased, motility gone

BODY DIMENSIONS. The sizes of pre-parasitic larvae fluctuate from 380 to 460 units* in length and from 13 to 17 units* in width. The tail is about 65-70 units* long, i.e. it approximately constitutes 15% of the entire body length (alpha = 23). Measurements of 43 parasitic larvae in the final stage, taken from various plants, have shown that their body lengths fluctuate between 380 units* and 650 units*. The average length of the body including the pin-tail, measured 465 units* of which 40-45 units* were taken up by the pin-tail; the average body diameter — 86 units*. The size of mature females is more inconsistant. The length of propagating females is rarely** less than 500-600 units* or more than 1000 units*. The females, however, stretch sometimes very much and reach a length of 1500 and even 1700 units*, but there are also dwarf females measuring 450 units* in length. The width of females is rarely less than 400 units* or more than 800 units*, but there are also strongly bulging females which are 1000 units* wide, and in dwarf females whose body length is 315 units*. The body length of females depends on the elongation of the neck, which sometimes, is drawn out extremely long. The length of males varied from 1 to 2 mm, but extreme sizes were rare and prevalent measurements ran between 1300-1700 units*. Measureing 53 males from various populations, the average length proved 1515 units*, and the average body diameter — 30-35 units*. At the anterior end the body narrows down to 11-13 units* at the base of the cap, yet the tip of the cap is only 7 units* in diameter. At the posterior end the body contracts less; at the base of the spicules its width reaches 20-22 units*. Looking at the tail from above or from beneath, there is no further contraction, but in profile the tail narrows down to 8 units*. [Begin p. 410] The tail is short; the opening of the cloacas is situated 8-15 units* forward of its tip.

From the example cited, it is apparent that a tremendous increase in the dimensions of the nematode body occurs during ontogeny (fig. 4). Taking the average measurements of various stages of development and assuming, for approximate calculations, that preparasitic larva is a cylinder 0.42 mm high and 0.016mm

* micron

** See errata at end of book

in diameter, and using the formula for calculation of cylindrical dimensions, we will find that its dimensions equal 0.000084 mm^3. In parasitism this phase expands rapidly, and the average size of the ultimate phase of parasitic larva can, approximately, be accepted as a cylinder 0.43 mm in height and 0.086 mm in diameter; its dimensions will be 0.002496 mm^3, i.e., as compared to preparasitic [larva], they will increase almost 30 times. Such an important increase in dimensions without molting in the same larval phase, is a rare phenomenon and, therefore, until of late, the parasitic phase was considered as the next larva of the nematode. After metamorphosis the female bulges out still more. Taking, approximately, the average size of the female for a sphere 0.7 mm in diameter, and using the corresponding formula, we will find its dimensions to equal 0.179594 mm, i.e., compared to preparasitic larva, the dimensions of the female increase more than 2000 times (2133 times). Such an enormous increase in the animal mass during ontogeny is typical of those parasites which settle down in the early stages of development, since it is to their advantage that each individual settling down have a minimal biomass, but that their quantity be maximal, and, in this direction, the evolution of parasites is strengthened by natural selection. The male, developed in larval skins and being smaller than the ultima phase of parasitic larva, ceases growing. Assuming, approximately, that the male is a very elongated cylinder, 1.5 mm long and 0.032 mm in diameter, we will find that its dimensions equal 0.001205 mm^3, i.e. 140-150 times smaller than the dimensions of the female.

Fig. 4. - Ultimate phase of parasitic larva of the root-knot nematode before the beginning of molting. Body very expanded, bulbus increased even more, tail reduced to pin at posterior end of body.

COVERING. Externally the body of the root-knot nematode is covered with cuticle composed of two distinct layers: the external one, transparent, divided by furrows into rings, and a thick internal one. Beneath the cuticle is located the hypodermis, adjoined by longitudinal muscular cells most of which degenerate in the parasitic phase. The thickness of the cuticle increases with age: in larva it reaches a thickness of 1.3 units*, in the male the cuticle gains in thickness up to 2.5 units*, and in the tail region — up to 4.5 units*, but in females — up to 8-10 units*, and in the bulbus region — up to 13-16 units*. In preparasitic and parasitic larva thickness of the cuticle was identical [Begin p.411] and Nagakura's assertion that it grows thinner in parasitic larva is erroneous. The cuticle of males with distinct rings is 2.5 units* wide; annulation in young females is also apparent over their entire bodies, but it is particularly distinct in the anterior part, and poorly visible at the posterior. In adult females the annulation is noticeable only in the neck region; the width of their rings reaches 2-2.5 units*. Annulation in preparasitic larva can be discovered only under great microscopic enlargement; the rings are very indistinct and very narrow, about 1 unit* in width.

HEAD-CAP. The head end of the nematode wears a so-called head-cap, named also head of the neamtode, which is divided from the body by a ring furrow. The head-cap is well developed in the motile phase — of preparasitic larva and the male, and it grows much shorter, though still remains, in parasitic immotile

* micron

phases. In invasion larva the height of the cap reaches 4-5 units*; in parasitic larva it is reduced to 3 units*, and in the female to 2-2.5 units*. In the male, the height of the head-cap reaches 5-7 units*. A relationship between the dimensions of the head-cap and motility is definite. Sometimes the cap is considered as an auxiliary organ of movement, assuming that it acts as a wedge. It is possible that the reduction of the cap in parasitic phases is connected with the reduction of the receptacles [Retseptory] found on it, and with the general reduction of the body.

Fig. 5. - Young female of the root-knot nematode soon after finishing the last molting. Body not yet much bulged out; transparent cuticle permits examination of internal organs.

NUTRITIVE ORGANS. (fig. 5). They begin with the spear or stilet of the mouth, situated in the cavity of the mouth. The spear represents a thickened, hardened distal [distal'naia] part of the chitinized internal tube of the esophagus and is punctured in the center by a canal passing directly into the canal of this tube. The esophagus which proceeds from the spear is composed of three sections: the anterior, the narrowest; the center or bulbus, of a more or less powerful muscular formation, and the posterior — glandular. Behind the esophagus rests the center intestine which passes into the sharply narrowed posterior intestine opening up as an anal aperture. The anterior in-take sections of the feeding organs are weak in invasion larva, the intestine is narrow; upon transition to parasitism, the strength and dimensions of all nutritive organs increase sharply, but in adult females they grow most powerful. In males, the nutrition organs again grow weaker. [Begin p. 412] In all phases of development, the root-knot nematode can feed on liquid food only, absorbing it through the stilet with the aid of bulbus contraction. The esophagus glands eliminate secretion which passes through the stilet and conditions extra-intestinal digestion, disolving the food before it enters the intestine; this method of digesting food is highly prevalent in nematodes.

THE STILET. The stilet is long and thin in preparasitic larva; its length varies from 12 to 14 units*, its width is about 1 unit*. Basal protuberances located at the base of the spear form an expansion of 2.6-3 units*. The spear has parallel little walls and is pointed only at the top. The stilet remains in parasitic larva as it was in preparasitic larva, since no molting occurs during/which the old spear could be cast off together with the cuticle and a new one could form. Nagakura's claim, rewritten by Filip'ev (1934), that the spear in larva within the root grows smaller is clearly erroneous. In females the spear becomes considerably more powerful; its length reaches 16-17 units*; the posterior part of the spear is cylindrical, the anterior part conic; basal protuberances stand out at the base of the spear in the form of three bulges. The thickness of the cylindrical part of the spear measures 2.5 units*, but at the base, in the area of basal protuberances — 5-5.5 units*. The measurements of spears in females cited by different authors are very distinct; this prompted Filip'ev to presume that different races of the root-knot nematode are prevalent in different countries. The figures of some author, however, are clearly erroneous and their measurements are refuted by further investigations of nematodes in the same country. The length of the spear in female nematodes was in Sukhumi

* micron

the same as in the USA, according to later and more accurate measurements accomplished there. The stilet in males is longer, from 18 to 23 units*. Form and width of the spear is the same as in females. Already Strubell (1888) described the muscle protractors and retractors moving the spear in the beet nematode. According to his description, the first were affixed to the basal protuberances, and the retractors to the center of the spear. The cuticle was the Punctum fixum for both pairs of muscles. The description is repeated for the root-knot nematode as well. According to our observations, there are only protractor muscles, and the pulling of the spear inside the body is its passive return to its former place.

ESOPHAGUS. The esophagus section in preparasitic larva represents a narrow tube, 6-7 units* in width and about 50 units* in length. The esophagus is hard to notice in this phase, with the exception of the internal, sharply protruding cuticle tube, about 1 unit* in diameter. During transition to parasitism, the anterior section of the esophagus expands considerably and changes into a fairly powerful cone-shaped formation, very easily noticed on living object. In the final parasitic phase, the width of the esophagus in front of the bulbus reaches 15-20 units*, thus growing almost 3 times as thick as in preparasitic larva. In females the esophagus grows still more powerful, but retains the same, generally cone-shaped form prevalent in parasitic larva. The internal cuticle tube of the esophagus expands very strongly, reaching 2.5-3 units* in diameter. In males (fig. 6), the anterior section of the esophagus becomes cylindrical and is not easily noticed, the same as observed in preparasitic larva. Only the internal chitinized esophagus lumen, 2 units* in diameter, is clearly visible.

The other section of the esophagus, or bulbus, represents an oval, solid formation. Radical muscles are situated in the wall of the bulbus, and in its center is located an oval cavity with thick cuticularized walls — lumen. [Begin p. 413] The lumen shrinks due to the reduction of radical muscles, but expands anew later, and thus causes the absorption movement. During ontogeny of the root-knot nematode, the bulbus, too, undergoes form and dimensional changes. In preparasitic larva, the bulbus is poorly developed and less clearly pronounced. Its measurements are about 13-15 units* in length and 10 units* in width. The measurements of the lumen are 5 x 4 units*.

Fig. 6. - Male of the root-knot nematode.

During transition to parasitism, the bulbus rapidly develops into a vigorous and easily noticeable organ, reaching, in the final phase of parasitic larve, 30-32 units* in length and 28-30 units* in width, increasing several times in size compared to its size in preparasitic larva. The bulbus wall grows strong, and the lumen retains the same measurements, — 5 x 4 units* — which it had in preparasitic larva. The bulbus attains the greatest vigor in females. Its measurements vary from 39-52 units* in length and 34-50 units* in width. Measurements occurring more frequently are: 47 x 44 units*. The measurements of the lumen fluctuate between 18 x 11 and 16 x 13 units*. In males the bulbus is poorly developed and again becomes poorly noticeable. Its measurements vary from 23 x 18 to 28 x 16; the measurements of the lumen are about 8 x 6 units*.

* micron

[Begin p. 414] The third section of the esophagus contains three mononuclear esophagal glands; a dorsal one and two subventral ones bordering on the intestine. The dorsal gland opens into the esophagal lumen -- at the base of the stilet, and the subventral one -- into the bulbus cavity. In preparasitic larvae these glands are narrow; in parasitic larvae they increase in dimensions at the expense of growth in width. The Glands in females expand even more, while those in males shrink again.

INTESTINE. In preparasitic larva the middle intestine is narrow, cylindrical, about 10 units* in diameter, turning into a very thin posterior intestine near the posterior end of the body. The anal opening is situated at a 65-70 units* distance from the posterior end of the body. The middle intestine is covered with drops of fat the size of which reaches 8 units* in diameter. During transition to parasitism the dimensions of the middle intestine increase very strongly. The figures cited for increases in larval dimensions characterize this growth, since the expansion of larva is due mainly to the growth of its intestine. The posterior intestine retains its previous form of an obliquoly set narrow tube passing from the center intestine to the body surface. As a result of reduction of the tail, the anal opening is situated closer to the posterior end of the body. In females, the middle intestine expands even more; in young females it takes up the larger part of the body, and in mature ones the intestine is pushed aside by growing sexual tubes. The drops of fat covering the intestine are large, about 20-50 units* in diameter. The middle intestine narrows down sharply and turns into the short and narrow posterior intestine. The anus rests at the posterior end of the body, not entirely terminal, but somewhat to the side; it can be seen clearly in young females, but becomes less visible in mature ones. There is no thickening of the cuticle around the anus, and due to this characteristic it can be easily distinguished from the sexual aperture. The middle intestine of males looks like a straight cylindrical tube taking up the larger part of the worm-body (at a 33 units* body diameter, the intestinal diameter equals 23 units*). The intestine ends in a wide cloaca which receives also the sexual organs of the male. The cloaca opens out to the surface as a transverse aperture near the posterior of the body, at a distance of 8-15 units* from the tip of the tail.

ORGANS OF ELIMINATION. In all nematodes, the function of the elimination organs is performed by the cutaneous glands, the so called cervical glands. Root-knot nematodes, the same as other representatives of the family Anguillulinidae, are endowed with the tylenchoid [tilenkhoidnyi] type of elimination organs characterized by the fact that the excretory canal and the gland cell are not paired, and rest in one lateral field of the hypodermis, in the root-knot nematode on the left side. The elimination organs have not been investigated, hence their variation during ontogeny can be indicated only with respect to the arrangement of the excretory pore. In preparasitic larva the excretory pore is easily visible; it opens in a level with the glandular part of the esophagus at 80-85 units* distance from the tip of the head. In parasitic larva, the excretory pore opens outwards, also on level with the glandular part of the esophagus. In young females the pore is situated on the level of the bulbus which obviously, is connected with the strong increase in the dimensions of the latter. In mature females the excretory pore is barely visible, yet in males it can be seen very well, and it opens, the same as in larvae, on the level of the glandular part of the esophagus, at a distance of 140-165 units* from the head-cap.

* micron

SEXUAL ORGANS. The sexual embryo forms in nematodes very early, but becomes clearly visible only in parasitic larva. In this phase the embryo represents an accumulation of spheric sexual cells which under the microscope looks like a flakelet [plastinka]. [Begin p. 415] The sex of larvae is undeterminable and the formation of sexual tubes from the embryo can be detected only during metamorphosis.

The sexual organs of the female are composed of two sexual tubes (fig. 7), which merge at the posterior end into one short tube — the vagina: the latter opens outwards as a sexual aperture — the vulva. The sexual tubes are long; the biggest one of the tubes which I measured reached 6 mm, with the length of the female being 0.85 mm, i.e. the tube was 6-7 times, and consequently, both tubes were 12-14 times longer than the body. In comparison with the relatively short sexual tubes of motile phytohelminths from the genus Anguillulina and Aphelenchoides, their length in the root-knot nematode must be recognized as very great. The ovary composes about 6% of the entire length of the sexual tube, and is its thinnest and brightest part. The globular ovogonia seen in the ovary are about 18 units* in diameter. Without any define borderline, the ovary turns into a wider oviduct [iaitsevod] which takes up about 55% of the tubes length. It contains ovocytes; at the beginning their form is globular, further on the ovocytes stretch across the tube and take on a wedge-like form, later they gradually stretch lengthwise along the tube and assume the oval shape of an egg in the distal part of the oviduct. The oviduct flows into an irregularly globular chamber termed semenreceptacle [semepriemnik]; it is 140-150 units* in diameter.

Fig. 7. Sexual tube of an egg-hatching female of the root-knot nematode.

The precise function of this organ is the separation of the shell surrounding the ovicells coming from the oviduct. The semenreceptacle (?) is followed by the uterus which takes up about 37% of the length of the sexual tube; in it are lying the fully developed eggs. [Begin p. 416] The uteri of both tubes merge into a short unpaired vagina. The sexual aperture is closed and surrounded by oval spindles [valiki] of the cuticle, forming around the vulva a sexual swelling [bugorok], which is plainly visible in a young female, but disappears in a mature one. The glandular cells, the secretion of which forms an ootheca during egg hatching, also open into the sexual aperture.

In males, the sexual tube takes up about 60% of the total length of the body; its length reaches 800 units* in a male whose dimensions measure 1300 units*. The proximal part of the tube is composed of the male sexual gland [semennik] with small cells of spermatogonia. Expanding gradually, the sexual gland of the male turns into a semen-duct [semeprovod], which contains larger wedge-shaped spermatocytes. The distal part of the tube is formed by the semen-emitting [semeizvergatel'nyi] canal, the length of which constitutes 45% of the entire length of the sexual tube; it contains spermatozoons lying very loosely and freely in the lower part of the canal. The semen-emitting canal opens into the cloaca; it contains two spicules 29-36 units* in length, on the average about 33 units*, equipped with special musculature. The width of the spicule base is 4-5 units*; they narrow down at the tip. The bases of the spicules are separated from each other by a space of about 7 units*, but their tips, but their tips converge. The cloaca also contains a "rod-ferrule"

* micron

[rulek] (gubernaculum) representing a thickening of the cuticle wall of the cloaca and serving as a slide and a support for the spicules; it is usually 8 units* long, and its width, at the widest part, measures 2 units*. Tail wings (bursa) are absent, but the cuticle surrounding the tail grows somewhat thicker.

MUSCULATURE AND MOTILITY. Skin masculature is poorly developed. The invasion larvae are slow-moving and sluggish animals; movements are accomplished by bending their long body. They lose motility rapidly during transition to parasitism. Parasitic larvae whose form has changed very little at the time they are extracted from the root, lie completely motionless without bending their body or trying to crawl, although it seems that the tail which has been retained would allow this. Only the anterior part of the body remains motile in parasitic larvae. Larvae removed from galls continually make probing movements with their head-end by bending it slowly in various directions and by pricking rapidly with the stilet. Females, too, are completely deprived of their motility. In females removed from galls the following movements were observed: (a) slow bending of the head-end of the body in different directions; (b) pricking with the stilet; (c) rhythmic pulsation of the bulbus. The Males are capable of crawling slowly, similar to invasion larvae. Structural characteristics of the nervous system and sense organs in the root-knot nematode have not been investigated.

The cavity of the body stretches from the base of the head-cap to the posterior end.

METAMORPHOSIS. DEVELOPMENT OF MALES AND FEMALES. The first molting of parasitic larvae occurs in such a manner that the cuticle which has become separated is not cast off, but covers, in the form of a hood, the new larvae lying inside. At first the separation of the body from the cuticle is observed at the posterior end: the pintail is emptied, the posterior end of the larvae moves forward and coils; somewhat later, it can be noticed that the body unloosens from the cuticle in the anterior part also. The spear is cast off together with the cuticle: its contour is plainly visible at the anterior of the skin of parasitic larva. The apertures which form between the larval body and the old cuticle are at first very narrow, but later on the body usually moves far away from the skin of parasitic larvae at the anterior and posterior ends. [Begin p. 417] The molting described is the first following the exit from an egg and the second one, if the molting within the egg is taken into consideration, and the larva formed within the skin will constitute the second phase upon its exit from the egg, and the third phase, if the larva within the egg is considered. We shall call it the third larva . The development of the third larva is not entirely completed. The cuticular formations intrinsic in the origin of the digestive system are not developed: there is no spear nor internal cuticular tube of the esophagus. This is a rapidly passing larval phase, in the words of Christie and Cobb "more theoretical than actual". The third larva molts quickly and is transformed into the fourth larval phase. The fourth larva lies beneath the cover of two cast-off skins: the thick external skin of parasitic larvae equipped with a pinlike tail and the very thin internal skin of the third larva . The latter can be seen only from the anterior and posterior ends, but usually not laterally, clinging closely to the external skin or to the larval body. The further development of males and females is strongly distinct.

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* micron

Fig. 8. - Young female of the root-knot nematode, developed inside of three larval skins.

DEVELOPMENT OF THE FEMALE. In the dêvelopment of the female, the fourth larva is just as theoretical as the third. I have been unable to find any difference in their structure: This is a, similarly, not fully developed organism without cuticularized parts in the anterior section of the esophagus. The bulbus is retained in both larvae and can be seen very distinctly. The glandular section of the esophagus has grown shorter, hence the intestine which is dark, thanks to the drops of fat, clings to the bulbus. Sexual tubes develop from the sexual embryo, but sexual outlets (vagina, secual aperture) have not yet formed and it is impossible to distinguish any organs behind the intestine. The anterior end of both larvae is very motile: the larvae twists constantly in different directions. It is possible that these movements help to cast off the skins. The molting of the fourth larva leads to the formation of the young female which lies under the cover of three membranes (fig. 8). The thin skin of the fourth larva resting at the very interior can be discerned only near the head-end of the female, sometimes also at the posterior end of its body. On its exterior is found a similarly thin skin of the third larva, and still more externally — a thick cuticle of the parasitic larva of the second age. When the young females development draws to an end, all her inherent organs are visible. [Begin p. 418] The anterior section of the esophagus is sharply distinct from the corresponding parts of parasitic larva due to the strong development of the cuticularized parts. Sexual outlets are clearly visible; the vulva opens out on a sexual protuberance. On the background of the intestine are observed brighter sexual tubes. Naturally, the developed female will be somewhat smaller than the final phase of parasitic larva, in whose skin it developed. Its further development leads to a strong increase in its dimensions, in length and particularly in width. The dimensions of her sexual tubes increase most during her growth.

Fig. 9. - Larva of the root-knot nematode male of the fourth phase in the process of elongation. The larva develops within two larval skins: the thick external skin of the larva in its second age and the thin internal of the third age.

Fig. 10. - Young male developed within three larval skins, before coming out.

DEVELOPMENT OF THE MALE. In the case of male development, the fourth larva which rests under the cover of two skins constitutes the prolonged developmental stage during which modification of form and structure of the animal occurs. At the beginning of this phase, the body of the fourth larva is just as thick and short as that of the third, but at the end of this phase it turns into a long and thin male body. The elongation of the body proceeds rapidly. The cast-off skin of parasitic larva is soon too short for the larva growing in length, and its posterior end coils. Later, the loop forms and, finally, the body grows so long that it can remain in the skin only by coiling in it several times. Such "cocoons" from the skins of parasitic larva of the second age, harboring within coiled larva of the fourth age; or males, is very characteristic of the ontogenesis of Heterodera (fig. 10**). Development of the male from

** See errata at end of book

the elongated fourth larva takes considerably longer than the time required for the elongation of this larva. The duration depends on temperature and is indicated on p. 423. Finally, the last molting occurs and the skin of the fourth larva is cast off. It can be seen on the narrow ends of the worm where the skin appears on the body of the male. The young male now rests, as does the female, under the protection of three cutucularized skins: The external thick cuticle of parasitic larva of the second phase, the intermediate thin and wide cuticle of larva of the third phase, and the internal narrow and thin cuticle of the fourth phase. The development of the male is completed fully during metamorphosis: he reaches his maximum growth, and the sex organs — full development. In males, still resting within the skins (fig. 10), spermatoids are clearly visible in the semen-emitting canal, hence it can be assumed that males are immediately capable of fertilization. The males which have departed from the skins ("cocoons") cease growing and, obviously, consume nourishment. In any case, the possibility of their consuming nourishment is just as limited as in preparasitic larva.

MORPHO-PHYSIOLOGICAL ADAPTATION OF THE ROOT-KNOT NEMATODE TO PARASITISM. As a result of the simple structure of the root-knot nematode, parasitism does not produce in it such important morphological variations as in animals constructed more intricately, nonetheless, these variations are greater than in the majority of other plant parasitic nematodes. The shape of the body and of the organs — sexual and digestive systems, i.e. those more complicated in the nematode change markedly. Yet, no specially big modification occurred even in those systems, and a second set of organs, acquired in the process of parasitism, did not develop. Skin musculature suffer a reduction and as a result of this the parasitic phases lose their motility. The post-embryonic development of the root-knot nematode produced greater changes. Even though it retained all four larval phases, inherent in nematodes, they were separated from each other by molting, but only the second one which at first, as the preparasitic one, proceeds in the soil, and later as the parasitic one in the plant, developed fully and consumed food.

Thus oligomerism [oligomerizatsiia] of the life-cycle (Beklemishev, 1945) which, by the way, is one expressed in a complete shedding of larval phases, but in their rudimentation, and is inherent in many parasites, was not observed in the root-knot nematode. Hence the duration of the existence of non-reproducing phases is shortened and the prolonged phase is only that of the mature female. A comparison of the post-embryonic development of the root-knot nematode with the development of other species of the genus Heterodera shows that it is the most specialized. This, together with the considerable morphological adaptation to parasitism, indicates that the root-knot nematode had turned to parasitism within the plant a long time ago. [Begin p. 420]

ECOLOGY OF THE ROOT-KNOT NEMATODE. ECOLOGY OF THE PREPARASITIC LARVA.

CONDUCT IN SOIL. The rate obtained in attempts to determine the speed of movement of preparasitic larvae of the root-knot nematode under microscope was extremely low — fractions of millimeters per minute. Because of their slow and sluggish movements, larvae of the root-knot nematode are sharply distinct from soil saprozoons of the genus Rhabditis and from predators of the genus Mononchus. We were unable to induce the larvae to quick movements of escape even by using sharp, plainly unpleasant irritants: injecting a heated needle or a drop of acid. With the aid of glass capillaries filled with various fluids and buried in sand with nematode larvae, we succeeded in establishing a positive reaction of the larvae to weak organic acids. Stereotropism of larvae — their inclination to come in contact with hard objects is also easily observed. Their reaction to light could not be detected. After even distribution of larvae in a Petri dish filled with agar and half of it darkened with black paper, no concentration of larvae in any part of the dish was observed, not even after they had been exposed for a whole day. There was no attempt to escape even from direct sunlight, although the sun killed larvae even in the autumn when heat was slight. Literary data concerning the speed of movement of invasion larvae under field conditions are available only in the works of the author (Ustinov, 1934, 1939): in the course of a season, the larvae moved over a distance of but 25 cm. Larvae, however, penetrate depth very considerably: In Turkmen, nematode galls are found on the roots of mulberry trees at a depth of 120 cm (Blinovskii, 1945). The larvae of some other parasitic nematodes also display poor motility. For instance, the larvae of the wheat nematode are capable of infecting plants seeded no farther than 30 cm from the infected grain (Leukel, 1924). Of representatives of the genus Heterodera, the more motile larvae were those of the beet nematode (Naunacke, 1922).

Retension of Invasion capacity. Consumption of food by root-knot nematode larvae begins only when they establish contact with the root, up to that time they live on the supply of embryonic fat. It is known that soil infested by the nematode remains in a state of black fallow [chernogo para] having been invaded in the course of many months, but the variations undergone by larvae during starvation were not investigated. Nor are there any indications that soil can serve as a supplementary source of nourishment for larvae; yet, by analogy with other soil animals, this is entirely possible. Invasion larvae are capable of remaining alive for a period of two months even in watch glasses with a small amount of water: they lived at our place from mid April until mid June, 1946. Cinsiderable variations have been observed in the external form of starving larvae. The drops of fat covering the intestine in young larvae are used up as they grow older, and bright striae, deprived of the fat, appear on the intestine. At first the intestine shows transverse striae, later the striae grow even bigger, but the dark ones grow thinner and, finally, the intestine turns entirely light, with but a small stock of fatty drops. The amount of fat characterizes the age of larvae and their capacity for invasion which decreases gradually. Experiments in introducing starving larvae into plants have shown that upon loss of fats on half of the intestine, the invasion capacity of larvae wanes, and in the case of a still greater loss (for instance, on 75% of the intestine surface), they lose their invasion capacity completely. [Begin p. 421]

Having penetrated the root after long starvation, the larvae, first of all, replenish their normal supply of fats, and this strongly retards their development. Having opened, in July, roots infested with such larvae eight days after invasion, we found that the larvae had not expanded and still had the form and structure of invasion larvae, but with a dark intestine covered all over with drops of fat. The degree of larva fatness can be ascertained with conventional symbols which make it possible to estimate the age and invasion capacity of a given larvae population, which, in turn, would permit a more thorough study of their ecology. Does, however, the loss of fat occur in soil just as rapidly as in water on a watch glass? Do larvae find supplementary sources of mourishment in soil?

To clarify this, the suthor [of the present article] conducted several experiments with a quantity of preparasitic larvae in humus enriched soil and in thoroughly rinsed sea sand. Larvae in amounts as equal as possible were placed in both media; this was accomplished first by obtaining a uniform suspension from freshly derived larvae in water and, then by measuring this suspension with a pipette in equal amounts. After a certain period of starvation, both media containing the larvae were washed off into flower pots containing soil, cleared of helminths by drying it in the sun, and indicator plants. In the first experiment larvae were starving for a month — from July 9 through August 9, 1946, at high temperature, no lower than 25°C. No larva capable of invasion was left in the sand, but the humic soil caused slight infestation: 8 galls appeared on a plant. In the second experiment the larvae were starving for 25 days: from July 29 through August 23, 1946, at the maximal temperature of that year, reaching 35-36°C in the laboratory. Sand produced no infestation this time either, but the humus enriched soil produced a very slight invasion: only 4 galls were found on a plant. The galls which developed were very small, and the larvae found upon their opening were strongly retarded in growth. In the third experiment the larvae starved for 22 days; from August 27 through September 16, 1946, at a temperature lower than in the preceding experiment. Larvae capable of invasion survived in the sand, but in a considerably smaller quantity than in humic soil: 100 galls developed on plants in the latter, but only 5 in the sand.

Apparently, all experiments produced similar results: in humus enriched soil the larvae retain their invasion capacity longer than in sand. This means that they find in humus sources of sustenance lacking in rinsed soil. An examination of starving larvae under the microscope showed that the loss of fat proceeded more rapidly in sand than in humic soil.

Life cycle and fertility of females. Conditions for Development of Males. When galls are opened in the summer, no dead females are found and this leads to the conclusion that they live through the entire season. When plants wilt in the fall, females survive their hosts to a considerable extent: in Sukhumi living females are easily found in December and even in January in the roots of tobacco plants withered long ago. By the same token, females continue to live long in branches of roots if they are kept in a moist chamber. [Begin p. 422] When root tissue decomposes to such an extent that it falls apart when rinsed in water, the females continue to live and the rhythmic protrusion of their spear and contraction of their bulbus can be observed under a microscope. There is no doubt that the capacity to live long on the supplies of non-vegetating and even dead plants, developed in mature females, is most favorable for the dissemination of the species with seed material.

The potential life cycle of the root-knot nematode apparently is very great, and its propagation may continue very long. Indications as to the life cycle of females are available only in the works of the author (Ustinov, 1934, 1939). In observing the hatching of eggs in boxes with collapsible walls, it was noted that the female hatched 1814 eggs in 70 days. But these magnitudes can in no way be considered as ultimate, since the energy of the female was interrupted by the dying of the root. The average life cycle of the female is measured by the summer months; a few of them overwinter and, under Sukhumi conditions, resume hatching eggs, but perish afterward.

Parthenogenesis is inherent in the root-knot nematode; reproduction without males is regular and normal.

A larbe number of males appears only if living conditions are worsened, primarily those of nutrition. In Sukhumi their number changes during the season as follows: in the spring males can be found developing from overwintered larvae. Only in rare cases do they finish metamorphosis successfully, in most cases they perish during the last molting. In the summer males are very rare, but in August and September, when invasion increases greatly, and it is clear that the plant is being thwarted, the number of males enlarges. Small end galls are frequently inhabited by males only, and the rate of their development here is several times higher than that of females in a similarly small gall. The appearance of a large number of males under worsened living conditions has been established also in the case of the beet nematode (Molz, 1920).

Climatic factors. Influence of temperature and humidity. Temperature. The influence of temperature on the root-knot nematode is so obvious that it was noted even by its first investigators. At first particular significance was ascribed to severe winters and the freezing of soil considered lethal for the nematode (Neal, 1889); (Stone and Smith, 1898); (Bessey, 1911). Further observations, however, showed that high propagation of the root-knot nematode is interrupted not by winter temperatures, but by summer temperatures, namely by insufficiency of the sum total of temperatures and the short duration of the period of effective temperatures. Low winter temperatures produce no lethal action on larvae in the soil, and the root-knot nematode overwinters successfully under field conditions in the Don Basin [Donbas], in White Russia and near Moscow, and also in the countries of northern Europe and in Canada. Experimental work investigating the influence of temperature on the rate of development of the root-knot nematode was conducted by Tayler (1933). She established heat totals required for the development of the root-knot nematode and to measure heat she used the conventional heat unit equal to temperature by 1°C above 10°C, effective for an hour; degree hours above 10°C. Ten degrees constitute the threshold of nematode development, while the retarding influence of high temperatures is observed above 28°C; but temperatures which substantially depress adult females begin only with 36.5°C. [Begin p. 423]. The author's observations in Sukhumi resulted in numbers very near to those obtained by Taylor. In our experiments, the development of a nematode within the root required a miniumu of 7478 heat units from the time it invades the plant until it begins to hatch eggs and, according to Taylor, this requires from 7000 to 8500 units. Between the different periods of development, this sum total of temperatures was distributed as follows (table 2).

TABLE 2.

Total temperatures consumed in development of different phases of the root-knot nematode within the plant

Period of Development	Duration of development in days	Average Temperature (in °C)	Total temperatures in degree hours above 10°C: Absolute	%
1. Development of larvae prior to molting	8	25.9	3070	41
2. Period of molting (metamorphosis)	5	25.9	1912	26
3. Development of female from immaturity to egg hatching	8	23.0	2496	33
	21		7478	100

Tayler, too, indicates very close figures: the development of larvae into a female which formed within the skin of parasitic larvae required an average of 3000 heat units, or 41% of the average temperature total needed for the entire postembryonic development; to complete molting — up to the appearance of the young female — 1800 heat units, or 25%, and for the development of the female from a young one to initial egg hatching — 2400 heat units or 34%. Our observations show that the totals of temperatures consumed in the development of the root-knot nematode in Sukhumi are the same as those in California. According to some observations, more heat is used up in the development of the nematode in somewhat hotter Florida, here the threshold of its development is not 10° but 12°, (Townsend, 1937). It would be most interesting to conduct similar observations in the northern regions of root-knot nematode distribution.

In the development of males the elongation of the fourth larva proceeds very rapidly: it was observed that the larva transformed overnight from a wide and short (length 450 units*, width 82 units*) into a long and narrow form (length 1150 units*, width 55 units*); the average right temperature was about 22°C. But the development of the male from the elongated fourth larva is protracted, even though the exact time has not been established, since all larvae removed from the galls perished. Observations of simultaneously invaded plants show that the development of the male within the elongated fourth larva lasts longer than the time required for the appearance of young females, and approximately the same length of time is needed for the development of distended females. Upon opening the galls, the skin of parasitic larvae in which male development takes place frequently breaks, the elongated larvae of the fourth phase are found in water and can be taken erroneously for fully developed males, which can lead to an inaccurate determination of the developmental period.
[Begin p. 424, para 1]

A protracted developmental stage is the embryonic one; according to Tayler, its completion requires 5000 heat units. However, the time indicated by Tayler herself falls below this magnitude. Thus, according to her observations, eggs developed at 27°C in 9 days, this means that their development used up 9x24x17= 3672 heat units. Our observations produced very close figures. On August 12, 1946 eggs were collected in the phase of two blastomeres, and on August 22nd invasion larvae crawled out into the water. Development had proceeded in ten days. Total temperatures for these days were 3784 Tayler units.

The embryonic development/consumed 33.5% (1/3) of the temperature total required for the development of the entire generation. Granulation development of the embryonic leaflets [listok] and formation of larvae of the first phase proceed very rapidly. In the case of the observations indicated above, this process was finished within four days following the initial granulation. The total temperatures for those days came to 1420 Tayler heat units, or 37% of the heat required for completion of the entire embryonic development. Thus, more than 60% of heat is required for the transition of the first larva into the second one, this, however, includes in the cycle of embryonic development, the process belonging to the period of postembryonic development.

In our observations, no definite relationship was noted between temperature and the number of eggs hatched by the female. At fairly constant summer temperatures, the number of eggs hatched per day varies considerably, and with different females, observed in boxes with collapsible walls, these variations differed. The number of Tayler heat units needed for one hatched egg, came sometimes to only 4, more often to 5-6 units, yet in some cases it rose as high as 20 units.

Heat formula. Knowing the total temperatures needed for the development of nematodes, and the lowest threshold of development, it is easy to work out a heat formula for computation of an approximate duration of development at a given temperature. It is known that heat formulas produce but orienting numbers

* micron

and represent the relation between temperature and speed of development in the form of a stright line, while it actually, is expressed by a hyperbola which coincides with a straight one [line] only at average temperatures. There is, however, no doubt as to the great practical convenience of such formulas. In their application, a substantial error can be expected only in instances of lower temperatures, when the temperature of plant roots, probably rises very rarely to magnitudes depressing nematode development. By taking the average, instead of the minimal, periods of development and by converting Tayler heat units expressed in degree-hours into degree-days i.e. dividing the temperature total by 24, we will obtain for the post-embryonic development of nematodes within the root, from their invasion to the beginning of egg hatching, the equation: $S = \frac{320}{t-10}$ and for the complete developmental cycle, from egg to egg, $S = \frac{500}{t-10}$, where S is the average duration of development in days, and t- the average temperature at which development occurs. Our observations of the duration of nematode development in flower pots standing in the shade, so that the temperature of the soil in the pots was very near the temperature of air (isothermic), have shown the following: [Begin p. 425]

1. In the early summer of 1946, development proceeded in 30 days; invasion was introduced in soil containing a plant on June 10th, the first ovipositors were noted on July 20th. The average temperature of the period equalled 20.8°C. As per formula, development should have proceeded also about 30 days (29.6).

2. Two observations were conducted in the middle of summer: a) Inoculation on July 21; beginning of egg hatching, August 14; duration of development 24 days; average temperature 23.7°C. According to the formula development should have lasted 23 days. b) Invasion was introduced on July 26; beginning of egg hatching, August 19; duration of development 24 days; average temperature 23.6°C. As per formula, development should have lasted upwards of 23 days.

3. At the hottest time of 1946, the duration of development was 21 days — from August 15 through September 5. Average temperature of this period = 24.9°C. According to formula, development should have lasted also 21 days.

We can see that the developmental periods computed during the summer according to the formula are very close to those actually observed. In our own experiments, we were, however, unable to note the time when the larvae penetrated the root, but only the introduction of invasion material into the soil. In the spring, at lower temperatures, development of the first generation of nematodes lasted from April 20th, when the larvae were introduced, until May 30th when the hatching of eggs began, i.e. 40 days. The average temperature of this period equalled 17.1°C. According to the formula development should last 45 days. The formula, as is to be expected gives a longer period.

Accurate data on the duration of root-knot nematode development in other parts of the USSR is not available; let us nonetheless dwell on certain observations for comparison with our data.

According to Kōbakhidze (1941), In Tbilisi, at a temperature with a 24-hour daily average of 26.7°C, the development from invasion to young females (as per author "females in phase of copulation") lasted 13-16 days. In 4-5 days, they "fully completed their growth and development" and "soon" began to hatch eggs. As we can see, accurate periods of development cannot be established from this text, but it is possible that it lasted about 20 days. As per formula, duration of development should be 19 days.

According to field observations of Brodskii and Zemlianskaia (1946), in Tashkent the spring generation of root-knot nematode developed from the 6th to the 31st of May. For this period the total effective temperatures according to 10-day averages of soil temperatures at a depth of 15 cm, was 334 heat units, a little more than the average total temperatures (320 units) taken for the formula. Hence, the period of development observed is very close to the one obtained with the formula: days observed were 25, and by the formula there should have been 24.6 days. Yet, the duration of development of the following generation is indicated by the authors as being 32 days -- from 13 June through July 15, although temperature was higher during this period, and the total of effective temperatures added up to 528 units, exceeding the total required for the preceding generation by almost 200 units. So great a prolongation of development could occur only in a case when soil temperatures has surpassed the optimum and has begun to depress nematode development. This, however, could have taken place only during certain days, since, during the observation period, the ten-day average [srednedekadnye] of soil temperature at a depth of 15 cm fluctuated between 24.1 and 27.8°C, i.e. it did not reach magnitudes depressive to nematodes. Hence, it is more probable that the authors failed to conduct field observations with sufficient accuracy.

Moisture. All nematodes are hygrophilous animals, but many of them are capable of falling into anabiosis at an impending decrease of environmental moisture. [Begin p. 426] However, we established by Frank (1885), larvae of the root-knot nematode are not capable of it. In contrast to a series of animal helminths, the eggs of phytohelminths lack also resistance of drying; this is understandable, since they usually remain within plants, seldom find themselves in external environment and do not serve for spreading invasion and, therefore, their great resistance is irrelevant to the continuation of the species.

Although experimental work on the duration of nematode survival in drying soil has been conducted (Jones, 1932; Godfrey, 1933 and others), soil moisture strange as it may seem, was not determined in these works and, therefore, the maximum drying survived by larvae has not been established. According to our observations, oothecae and larvae of the root-knot nematodes perished when placed in soil dried in the sun, i.e. in actually air-dry soil in the summer, within the first 24 hours. But a large volume of soil retains a certain amount of water, in addition to that adsorbed, and this water maintains the moisture of soil air in a state of saturation and contains eggs and larvae.

Fig. 11. - Decrease in soil invasion upon drying. Broken line — invasion capacity; continuous line — water-holding of soil.

To determine the lethal action of dried out soil, the author [of present article] conducted a few experiments in 1946: in the moist climate of Sukhumi these experiments are possible under laboratory conditions only. All experiments produced similar results: loss of soil moisture up to 4-5% of the total moisture-holding kills all phases of nematode development and renders soil invasion aversive. Reduction of soil invasion in an experiment with the largest quantity of soil (about 10 buckets) spread in a large aquarium and dried in the shade is shown on the diagram (fig. 11). The experiments have shown that the root-knot nematode survives soil dryness such as cultivated plants could not survive. As a measure for nematode control, drying-out under field conditions is feasible only in the most arid region of the Soviet Union.

Yearly Developmental cycle of the root-knot nematode in Sukhumi. Throughout the wintwr, the root-knot nematode is easily found in the roots of many plants, not only the woody plants, but also in herbaceous ones vegetating during the warm Sukhumi winter. The root-knot nematode is found in all phases of development (except male). Nematode development retarded by winter chills is resumed in April. Mature females again begin to hatch eggs; yet, their sexual activity in the spring does not last long: in May, all females obviously die. Parasitic larvae overwintered in roots proceed to molt; they, however, also perish in the large majority of cases before they finish molting. Fully viable are the overwintered invasion larvae and eggs. Many more larvae overwinter in soil than in plants; [begin p. 427] invasion of plants begins in April. The size of nematode population in the soil decreases rapidly during the winter. Thus, in the fall in the same garden, 2000 cm^3 of soil produced 400 galls on a plant, yet in spring we were entirely unable to infest a plant with the same amount of soil. In May, population statistics of the root-knot nematode are at a minimum. In June they begin to grow due to reproduction of females of the spring generation. Once begun, reproduction continues steadily; females propagate for a very long period and they still continue hatching eggs after several generations have developed from the first groups of eggs hatched.

Thus, there is established a steady flow of reproduction of nematodes in all stages of development; there are no separate generations, and the term "number of generations" should be interpreted as their largest possible number, the number which we would obtain if we considered only the offspring of the older ones as indivisuals of each generation appear.

The number of generations can be established if the total of temperatures is calculated as being higher than the threshold of development and is divided by the temperature total required for the development of one generation. The quotient of this division will give the number of possible generations. The accurate number of generations developing during the season can be determined experimentally by riasing nematodes on plants in containers and subsequently, infesting fresh plants with the eggs of each new generation. We used both of these methods; first we, naturally, used the calculation method, for it is very quick and simple. Calculations have to be conducted on air temperature, since the temperature of soil varies considerably due to insolation and other factors.

Table 3.

Total temperatures above 10° in degree-days according to air-temperature average of many years in Sukhumi

Months	III	IV	V	VI	VII	VIII	IX	X	XI	Annual
Total Temperatures	10	84	226	330	415	424	318	207	78	2092

Having infested plants at the very beginning of the season, over-wintered invasion larvae cannot finish their development, nor can they begin to propagate before the end of May, when total temperatures in 320 degree days needed for post-embryonic development, can be reached. Invasion larvae can develop from the eggs hatched in mid June (about 160 degree days), and post-embryonic development can be completed and propagation of the second generation begun during the second decade [10th-20th] of July, when total temperatures reach the necessary 500 degree-days. Eggs hatched by the second generation will produce the third generation which will reach maturity about the middle of August and will initiate the beginning of the fourth generation. The fourth generation will begin to propagate during the second half of September. Total temperatures are no longer adequate for the development of the fifth generation. Judging from the monthly average of air temperatures, in Sukhumi the seasonal capacity is upwards of 4 generations. [Begin p. 428] If soil temperatures on the southern slope were used in the calculations, then the seasonal capacity would increase up to 5 generations. In 1946 the number of generations was studied experimentally by means of successive intertwisting. Tracing the seasonal progress of the development of generations under observations (fig. 12) and comparing it with the chart on generations computed by total temperatures, we were astonished by their great coincidence, which may have been due to the fact that the temperatures of soils is very near to the temperature of air and, in 1946 (excepting autumn), the latter varied very little from the average of several years. In the fall, infestation of plants is at a maximum, the same as the amount of invasion larvae in the soil. From 5 gr. of soil taken from a tobacco field, we removed in early November up to 54 larvae of the root-knot nematode by the funnel [voronochnym] method; this comes to more than 10 thousand larvae per kg of soil. There is no doubt that all possible generations of nematodes develop successfully on annual plants only in rare cases, since vegetation of many plants ends before low temperatures set in and the reproduction potentials of the root-knot nematode are not fully realized.

Fig. 12. - Yearly progress of development of generations of the root-knot nematode calculated (broken line) by the total of average temperatures and established experimentally (Continuous line).

Fig. 12. - [Directly under graft] reads as follows:
April May June July August September October

Probable Developmental cycle of the nematode in other parts of the USSR. The close coincidence between the progress of calculated and actually observed nematode generations in Sukhumi justifies the use of the method for calculation of total temperatures also for other areas of the USSR. The method is less promising for northern rgions, since development proceeds more rapidly at lower temperatures than it ought to, according to the formula, and this means that total temperatures will be lower. In the republics of Central Asia, retarded development, possibly, is the result of superheating. For calculation, we used the world agroclimatic Hanbook (1937). It contains computed total temperatures for periods above 10° and indications of the duration of these periods. To obtain totals of effective temperatures, it is necessary to subtract the number of degrees below 10 from the figures cited; this is obtained by multiplying the number of days of the period by 10.

Let us examine the probable cycle of nematode development in Turkman. Totals of effective temperatures reach: at Ashkhabad — 2200, at Bairam-Ali — 2300, i.e. a little more than at Sukhumi; these localities, however, are distinguished by an early and warm spring. Total temperatures adequate for the development of mature females from overwintered larvae will be reached as early as mid May, and invasion of plants by newly developed larvae will begin at the end of May, earlier than in any other area (naturally, with the exception of the bordering southern part of Uzbekistan where it is even hotter). [Begin p. 429]. The second generation will begin to multiply during the second decade [from 10th -20th] of July, the third — during the second half of July] Here, mass nematode propagation and mass invasion of plants will begin earlier than in Abkhazia, hence it is natural to expect greater damage from the parasite. Seasonal capacity — up to 5 generations.

In Baku, total of effective temperatures — 2290, the same as in Bairam-Ali, but their distribution by months is different: in the spring there is less heat, in the fall more. The first generation of the root-knot nematode developed from overwintered larvae can begin to multiply only in June, almost a month later than in Turkmen. The second generation will begin to multiply about the middle of July. Seasonal capacity — 4-5 generations.

In the Ukraine, the total of effective temperatures is practically everywhere below 1500. The root-knot nematode has been distributed considerably in the area of the Donets river.

Fig. 13. - Probable seasonal progress of development of generations of the root-knot nematode in some parts of the Soviet Union, calculated by total temperatures. Continuous line — Bairam-Ali; dotted line — Voroshilovgrad; broken line of dots and dashes — Minsk.
[Directly under graft] reads as follows:
April May June July August September October

To characterize this region we shall use the data on Voroshilovgrad. Here, the total of effective temperatures is 1300. Propagation of females developed from overwintered larvae may begin in mid June, and invasion of plants by new larvae - about July. The second generation of nematodes will begin to multiply about the end of July, in warm soils even the third generation can develop.

To characterize conditions of development of the root-knot nematode in White Russia, we shall use the data on Minsk. The total of effective temperatures in Minsk is 580. This permits overwintered invasion larvae to reach maturity and to multiply for some time, but a second generation of nematodes cannot develop. As per observations conducted at the White Russian quarantine laboratory in 1935, reproduction of nematodes (apparently those developed from overwintered larvae) began during the first decade [1st to 10th] of July. Consequently, the total of effective temperatures for this very hot month comes to 232. Invasion of plants by new larvae is possible only in the last days of July. These larvae cannot complete their development, since average temperature of the third decade of August is below 15°. In annual plants, larvae gone over to parasitism are doomed. Nematodes overwinter in the soil in the form of eggs and invasion larvae. Under these climatic conditions, mass reproduction of root-knot nematodes is not expected, hence a heavy invasion of plants under field conditions is hardly probable. [Begin p. 430].

All of these calculations are made on air temperatures and can be considered only as tentative. In this form, they are however, very useful in estimating the possibility of mass reproduction and its consequences.

ROLE OF PREDATORS AND PARASITES. Among the inhabitants of soil are found many enemies of the root-knot nematode; they all destroy only preparasitic larvae; enemies attacking nematodes within the galls have not as yet been described. Thus, the root-knot nematode is safe from their exacting action during a large part of its life. Fifty-two enemies of the root-knot nematode have been found in Hawaii (Linford and Oliveira, 1938); most of these parasitize on other nematodes as well, and some attack each other. The list of these enemies includes 18 species of fungi, 1 of protozoa, 24 of predatory nematodes, 6 of mites and 3 of tardigrada. The normal activity of organisms limits the nematode population. Apparently, the animals which cause the most important damage to nematode larvae injurious to plants are predatory nematodes of the genus Mononchus. We had a Mononchus female living in a watch glass in a moist chamber for a month, feeding exclusively on larvae of the root-knot nematode. A report on an observation of one specimen of Monochus papillatus which destroyed 83 larvae of the root-knot nematode in one day is available in literature (Proceedings of the root-knot nematode conference, 1937). In Abkhazia, the numerical strength of Monunchus has the same seasonal progress as the root-knot nematode; these predators are more copious in the fall months. Of a large number of fungi parasiting on nematodes, the most important are the nematode catching fungi of the genus Dactylella. Tricellular rings resting on bicellular pedicels form on the hyphae of these fungi when nematodes are present. If a nematode enters one of these ring, it causes a rapid swelling and a contraction of the ring cell, and as a result the worm is tightly compressed. Later, the fungus hyphae grow through the body of the nematode and destroy it. Fungi of the genus Arthrobotrys and Cystopage catch nematodes with the aid of viscous substances isolated by the hyphae (Drechsler, 1937, 1944). The reduction in root-knot nematode population, noted long ago, can be explained by the increased number of its enemies in the soil due to the influence of an abundance of decomposed green fertilizers. Decomposition of plants facilitates the propagation of saprozoic nematodes by supplying them an abundance of food, which, however, leads to an increase in the number of their enemies. The latter attack also the larvae of the root-knot nematode which, at first constitute a considerable part of the nematode population in infested soil, but later, their number ceases to increase, because they are incapable of developing on decayed matter.

RECIPROCAL RELATIONS BETWEEN THE ROOT-KNOT NEMATODE AND THE PLANT. Investigation of the morphology and the development of the root-knot nematode shows that its historically developed adaptation to parasitism is greater than that in other plant parasites of the genus Ditylenchus and Aphelenchoides. It is to be expected that the interrelations between the root-knot nematode and the plant will also be more complex. [Begin p. 431].

Conduct of nematode and reaction of plant. Penetration of root. Invasion larvae are assisted in finding plants by the acid section [otdeleniia] of the roots causing positive motive reaction (chemotropism) of the larvae and a tactile influence (stereotropism) prompting them to maintain contact with the root once it has been established. Larvae may begin to feed on a plant while still outside the root by piercing the cell walls with their stilets. Introduction of invasion larvae in water into the root cannot be observed, because action of the stilet requires that the body have a buttress. This phenomenon can be studied on agar slides by preparing 3% agar and pouring it on petri dishes. The larvae penetrate into the root between cells or through the gap made by the stilet in the cell wall. They can gain access only in the area of young cells, hence infestation can occur only in the meristematic area of the root. Within the root, the larvae can roam two-three days, consuming food more energetically and moving mostly between cells without injuring them. Finally, they become fixed in a certain position so that their heads are lying in the pleroma, [pleroma] and the body — in the parenchyma of the rind. Larvae frequently infest also the subsurface parts of stems and tubers, but their infestation of the surface parts of a plant occurs rarely and must be considered as aberrant cases of parasitism.

Effect of larvae on plant. Mechanical injuries inflicted by larvae while penetrating the root, as well as during their migration within it, are usually insignificant which, undoubtedly, is most favorable for the further subsistence of the parasites. Larvae fixed in a root, soon lose motility and are no longer capable of leaving the root in case it dies. Furthermore, to form giant cells, nematodes must feed on undamaged young cells. Plant helminths which do not lose motility, for example, Pratylenchus pratensis (de Man), inflict on the plant considerably greater injuries during their migrations within its root.

The chemical action of larvae on the plant is much stronger; it is exerted by secretion of the esophageal glands isolated during feeding and begins to develop while the larvae still migrate within the root. Secretory action appears the strongest on the meristem and on the parenchyma of root rind. The former becomes depressed: division of meristem cells is thwarted, and growth of the root is interrupted or retarded. In a case of heavy infestation, growth of the root ceases forever, as a result of which club-shaped galls form on the ends of small roots. More often, growth has been observed to recommence after a period of retardation, this is connected with the resumption of activity by meristematic tissue. Dimensions of parenchymal cells of the rind increase due to secretory action of the root-knot nematode; their hypertrophy is responsible for a thickening of the root which sometimes is discovered already on the second day following invasion.

Action of precipitated nematodes. After fixation, the nematode body becomes immotile, with the exception of the anterior part which retains the capacity to move in the dorsal, abdominal and lateral directions. Nutrition consists of constantly recurring cycles including three actions: 1) puncturing the cell walls with the stilet; 2) injecting secretion of the esophageal glands into the cell and 3) sucking out a certain part of the cell contents. The parasites secretion falls directly into the plerome cells bordering the nematode head, and retards their differentiation; [Begin p. 432] further, some of the undifferentiated cells begin to increase in dimensions, and their nuclei divide without the subsequent fission of cells; then the barriers between the neighboring cells gradually disappear, their contents merge and form the beginning of a giant cell. The huge cells which at the beginning are not large, continue to grow due to the inclusion of the neighboring cells, but their fusion with one another was not observed. As per our measurements, the largest giant cells reached transversely 260 x 221 units*; lengthwise the giant cells are larger. We counted 20 nuclei in them, but reports in literature indicate over 500 nuclei. Elements of the central cylinder which surround the giant cells also undergo changes; some tracheata and vessels are ruptured in the gall area, others passing by the giant cells are merely turned aside. The secretion of the root-knot nematode exerts a stimulating action on the cells of rind parenchyma, causing considerable increase in its dimensions. Hence, the thickening of the root, observed at times during larvae migration, increases strongly after nematode fixation. The essential mass of root-knot nematodes is composed of parenchyma cells. Yet, the number of parenchymal cells within the gall and of those outside it is the same, but cell dimensions within the gall increase by several times. Thus, in cucumbers, the size of parenchymal cells in the gall equalled 160 units*, and in the

* micron

same root outside the gall — 75 units*, i.e. by assuming that the form of cells is cubic, their dimensions increased by 9 times ($160^3 : 75^3$); in tomatoes dimensions increased by 15 times, in sweet potatoes — by 6, and in the Acalypha weed — 4 times. Action of nematode secretion causes activation also in pericycle cells: they proceed to divide increasingly, and this leads to the formation of lateral roots which frequently branch out from nematode galls in large number.

The external appearance of galls. The external appearance of galls changes considerably during the season. As spring approaches, small separate galls, 1.5 mm in diameter, cuased by one, more often by two parasites, develop on thin roots. At the beginning of reproduction, the walls of such galls burst open and oothecae form outside of them. The dimensions of galls expand as invasion increases, and at the end of the season, the predominant type constitutes a strong swelling on large sections of the root. The size of galls depends on the magnitude of the root, in larger plants, such as squash or tomatoes, they reach 20 mm in diameter. A special group is composed of club-shaped end galls, usually small in size, about 1.5 mm in diameter, formed as a result of a simultaneous mass invasion of the root by so large a number of larvae that they interrupted root growth. On perennials, galls sometimes reach enormous dimensions. In Florida, galls on Thunbergia laurifolia were described as being 45 and 60 cm in diameter; they had developed on the roots and at the base of the trunk (Steiner and Buhrer, 1934). On the other hand, galls were found to be poorly developed and on some plants completely absent; in the latter case rind parenchyma does not expand, but a yellow spot forms around the female, since the root-knot nematode does not cause these plants hypertrophy, but cell necrosis. The absence of galls is characteristic of sweet potato and Gerbera.

Importance of gall formation. The importance of the described reactions of the host organism to the introduction of the parasite rests in the isolation of the parasite and the localization of toxins discharged by it. There occurs, at the place of nematode fixation an increased influx of nutritive substances; [Begin p. 433] granular impurities accumulate in the protoplasm of gigantic cells which, according to Kostoff and Kendall (1930), develop as a result of molecular condensation and consist of protein granules. The influx of abundant nutritive substances serves the plant as a means of localizing foreign matter discharged by the parasite, but it is also very favorable for the parasite which obtains a large amount of food concentrated in a small area, and around its head at that. The formation of galls, occurring as a result of hypertrophy of rind parenchymal cells, serves as a means for isolating the parasite from other parts of the plant. Galls, however, are very favorable for nematodes since they protect them from predatory soil organisms, insure them against drying out and establish around them a very constant external environment.

Thus, the protective reaction of the plant which is costing it a great deal and is causing the expenditure of a large amount of plastic and nutritive material, naturally, to the detriment of other organs, is very useful for the parasite. This conditioned by the inadequacy of the reaction itself to profit from the protective function of the host organism, but chiefly by the adaptation of the parasite and its ability to adapt itself to specific living conditions. As a result, the protective reaction of the host becomes a necessary requisite for the very existence of the parasite.

Dimension of females from large and small galls. It is to be expected that conditions for the development of nematodes will be more favorable in large galls than in small ones and, therefore, females will grow bigger in large galls and will hatch more eggs. Measurements confirm this hypothesis, (Table 4).

Table 4.

Measurements of females of the root-knot nematode from large and small galls.

Plant and appearance of galls	Number of measurements	Measurement of females (in units*)	
		Length	Width
Tomatoes:			
Large galls	100	983 ± 111	704 ± 86
Small galls	96	643 ± 100	475 ± 72
Tobacco:			
Large galls	141	928 ± 116	682 ± 116
Small galls	143	640 ± 80	470 ± 83
Blue Eggplants:			
Large galls	57	990 ± 170	637 ± 91
Small galls	36	713 ± 81	490 ± 70

* mu

Varying curves of female dimensions of the root-knot nematode from large and small galls on tobacco are shown on fig. 14.

Comparative action of different nematode species on plants. Hypertrophy of adjacent cells is a very frequent reaction of the organism to introduction of the parasite. [Begin p. 434] Some helminths (for instance, nematodes of the sub-order Spirurata) cause tumors in animals; expansion of plant cell (helminthocecidia) is caused by all nematodes of the order Anguina and Heterodera, while other nematodes, such as Ditylenchus and the leaf parasites of the order Aphelenchoides cause tissue necrosis. The latter reaction is, undoubtedly, more primitive and very injurious to the plant, as well as to the parasite, forcing it to move from dead tissue to a living one. This is achieved either by direct nematode migration, or observed in chrysanthemum nematodes — Aphelenchoidos ritzemabosi (Schwartz), by their transition into an anabiotic state and by spreading of invasion with dry leaves. If the parasite loses motility and becomes incapable of anabiosis, then tissue necrosis will cause its destruction. A sign of an even lesser adaptation of the parasite to the host is the strong mechanical destruction of plant tissues, and the nematodes causing such destruction, as for instance Pratylenchus pratensis (de Man), must be considered as more primitive parasites. The interrelation between the root-knot nematode and the plant must on the contrary be considered as very complicated.

Fig. 14 - Variation curves of female measurements of the root-knot nematode from large and small galls on tobacco. Continuous line — body length of females in small galls; punctated — same in large galls.

The internal structure of Heterodera galls is distinct from the structure of other nematode galls. A nutritive zone feeding the parasites and surrounding the internal cavity harboring the parasites forms in the galls caused by Anguina as well as in those caused by gall flies; but in the galls of Heterodera the function of the nutritive zone is fulfilled by giant cells. The ability to cause formation of cell syncytia [sintsitiev] is a specific characteristic of the genus Heterodera, inherent in all of its representatives.

There are no data in literature concerning the nature of secretions isolated by the nematode, not even a hypothesis has been voiced on this subject. However the similarity of the action of secretions of the root-knot nematode to that of growth substances on plant is immediately obvious: the latter stimulate root growth when their concentrations are very weak, yet their stronger concentrations retard growth and cause thickening of the root. According to Kholodnyi (1939), the action of higher dosages of growth substances interrupts the growth of a root in length almost completely, yet at the same time there forms a thickening in the section subjected to their action, and after 24-hours it develops into a rather considerable swelling. Anatomic investigations show that the thickening consists of rind parenchyma cells strongly expanded in width; [begin p. 435] the central cylinder also thickens, but to a considerably lesser degree. The development of lateral roots is accelerated. Maksimov (1946) believes that the basic function of growth substances rest in their supplying water and nutritive substances to the area of their action. Of great importance to the effectiveness of growth stimulants is the age of tissue: their action on young cells is considerably stronger.

The similarity between the action of root-knot nematode secretions and that of growth substances prompts the assumption that their concurrent action would produce a stronger reaction of plants and the formation of bigger galls. Experiments confirm this hypothesis: by planting cucumbers in soil strongly and very evenly invaded by root-knot nematodes, and by wetting a part of them with a solution of a-naphthyl-acetic acid of 0.01 and 0.02% concentration, we obtained considerably larger root expansions on the plants treated, than those caused by one nematode; the latter were 1.6 times thinner than the expansions caused by concurrent action of a nematode and growth stimulants.

QUANTITATIVE CALCULATIONS AS TO ROOT-KNOT NEMATODES IN PLANTS. The method we used for a quantitative calculation of root-knot nematodes in plants was the following: a piece, as correctly cylindrically shaped as possible, was cut with a razor blade from a gall, and then cut up with preparatory needles [preparoval'numi iglami] in water into pieces so small that the nematodes it harbored washed out. The water with the suspended nematodes was distributed with a pipette on a slide [predmetnoe steklo] in a narrow strip and the nematodes were counted under a microscope. Invasion larvae, not yet in a state of parasitism, were not taken into account. The dimensions of the investigated piece of gall was calculated as per the formula used to determine the dimensions of cylinders. Calculation of developing galls showed that, in proportion to nematode development, the average size of a gall, designed for one nematode, increases considerably. Thus, in the early developmental stage of a gall containing only parasitic larvae, the average space per parasite was 0.14 mm^3, but at a later stage, when galls are already harboring young females, the average space increases up to 0.5 mm^3. In old galls containing egg-hatching females, the average gall space per parasite was even bigger, although not consistently, as seen on table 5.

The population of club-shaped end galls is more dense than throughout the root: in these galls, the average spaces assigned to one parasite does not exceed 0.67 mm.

To obtain an average number of the root-knot nematodes within the entire root system, we measured the galls and calculated their dimensions on two plants. In the case of a blue eggplant, we obtained general gall dimensions amounting to 94341.3 mm^3, and for a tomato (on which small galls were not counted) — 188627.6 mm^3. Assuming, on the basis of data on table 4, that the average space of a gall assigned to one parasite is 1.6 mm^3, we shall find that the average number of nematodes parasiting the galls of the blue eggplant was about 59 thousand, and for those parasiting the galls of the tomato — about 118,000. The average space of a gall assigned to one female is 3.4 mm^3. Thus, the roots of the blue eggplant were inhabited, approximately, by more than 27,000 females, and the roots of the tomato by more than 55,000 females, i.e. in strongly infested plants they are found in tens of thousands. Since the fertility of each female amounts to more than a thousand eggs, those females will produce tens of millions of eggs and invasion larvae. [Begin p. 436, below table 5] Just what mass of living matter is composed of nematodes parasiting in roots? Assuming that the average dimensions of a female are 0.179 mm^3, we find that their number, as calculated in the case of blue eggplant, will constitute a bulk of about 5,000 mm^3, and the amount calculated for tomatoes — about 10,000 mm^3. The mass of living matter of females is, approximately, 79 times larger than the mass of living matter of other phases, and the principle devourer of plant substances are the females. On the strength of the prolonged process of egg-hatching, the females have to absorb a great deal of nutritive substances systematically, and this alone is enough to exhaust and to weaken a plant. The amount of secretion they isolate is also much larger than that isolated by larvae, hence intoxication on the part of females must also be considerably greater. This is confirmed by observations over the growth of galls and the beginning of plant depression.

Table 5

Quantitative calculations of the root-knot nematode in large old galls on blue eggplant, in October 1946

Size of piece of gall considered			Number of different stages of nematode development		Average gall space (in mm^3) taken up by one parasite	
Length (in mm)	Width (in mm)	Dimensions (in mm^3)				
5	16	1004.8	Parasitic larvae -	167	For all stages	2
			Female	168	for females	6
			Males	165		
			Total	500		
4	11	379.9	Parasitic larvae	3	For all stages	1.5
			Females	109	For females	3.4
			Males	96		
			Total	208		
5	7	192.3	Parasitic Larvae	7	For all stages	1.9
			Females	91	For females	2.1
			Males	4		
			Total	102		
10	10	785	Parasitic larvae	110	For all stages	1.7
			Females	171	For females	4.5
			Males	160		
			Total	441		
11	3	35.3	Females	29	For all stages	0.95
			Males	8	For females	1.2
			Total	37		

[Begin p. 437]

INOCULATION OF MICROBES. Apparently, all nematodes — plant parasites — are capable of inducing pathogenic microorganisms into a plant. This applies also to facultative plant parasites, such as Apholenchus avenae Bast. which introduce fungus hyphae by stilet piercing (Christie and Arndt, 1936). So much the greater must be the role of obligate parasites which break into the plant and violate the wholeness of its integuments. As per observations in different areas in England, the strong fluctuations in the potato nematode's capacity to injure depend on the diseases connected with it (Triffit, 1931). Root rot of tobacco is considered a compound disease caused by penetration of the root by a complex of pathogenic organisms consisting of nematodes, more often Pratylenchus pratensis (de Man) and of fungi. In the USSR maceration of tau-saghyz roots is explained by the combined action of nematodes and microbes, with the primary role being ascribed to nematodes (Kalinenko, 1933, Sveshnikova, and Skarbilovich, 1937). The fact that infestation of plants by the root-knot nematode is accompanied by fungus diseases was noted already by Jobert (1878) with regard to coffee trees in Brazil. Since then, the combination indicated has been confirmed by a large number of conducted observations; obviously heteroderosis is always a combination disease. An especially big role is ascribed to the root-knot nematode in the accumulation of Fusarium vasinfectum — the causal agent of cotton wilt. The nematode is an accessory to wilt in tomatoes in which the disease is caused by another form of Fusarium. Apparently, the connection between the root-knot nematode and Fusarium is closer than with other pathogenic fungi, which is explained by the fact that heteroderosis as well as fusarioses [fuzariozy] belong to the first immunogenetic group, according to Dunin's (1946) system, i.e., they attack ontogenetically younger roots. In the USSR, a combination disease of the root-knot nematode and fungi was observed in a section of lavender on a sovkhoz near Sukhumi, but the required investigation of the disease has not been conducted.

PATHOGENESIS OF THE ROOT-KNOT NEMATODE. As a result of root-knot nematode infestation, the plant is stricken by a protracted disease — gall heteroderosis. As is the case with other diseases, the course of heteroderosis may be either slight or serious. Subsequent to the chronic course of the disease and prolonged isolation of foreign matter, the disease spreads rapidly and affects a large number of plants, i.e., it has the tendency to assume an epiphyte character. Frequently the disease proves fatal to the plant and young plants may perish before producing their first yield; this was observed in the southern republics of the USSR on the seedlings of fig, peach and mulberry, and also on vegetable plants. The direct reason for the destruction is decomposition of the root; large galls always decompose, and whenever destruction of the root system is considerable, the plant perishes; in the case of annuals, destruction is usually observed at the end of summer. In slight infestation the disease passed unnoticed, though it is only very rarely that it does not exert influence on plant growth and yield (later on this is true also of a slight infestation of annual plants). In the USSR the root-knot nematode causes damage in the southern republics of: Gruzia, Azerbaidzhan, Turkmen, a little loss in Uzbekistan. Work conducted there recorded much nematode damage (Blinovskii, 1945; Brodskii and Zemlianskaia, 1946; Klechetov, 1947; Kobakhidze, 1941; Selivonchik, 1938; Ustinov, 1934 and 1939). [Begin p. 438] Estimates made of yield losses caused by nematodes to various crops were quite considerable. According to our calculations, in Sukhumi the weight of tobacco plants badly infested by the root-knot nematode dropped in different calculations by 31-71%, and in average by 57%. In a zone where the total of effective yearly temperatutres reaches 2000 (in degree days), and above, the great harm done by the root-knot nematode under field conditions cannot be doubted. In areas of a temperate climate, much harm caused by the root-knot nematode in the field is recorded for Alma-Ata (Litvinova, 1939b) where the yearly total of effective temperatures is about 1300. In our opinion, the figures of losses cited by the author are extremely high and need checking. It is possible that here the nematode acted in conjunction with microorganisms more pathogenic to plants. In greenhouses and in conservatories the root-knot nematode can cause great losses and even destroy completely the yield of any latitude.

PLANT IMMUNITY TO THE ROOT-KNOT NEMATODE. By immunity is meant the aggregate of plant properties inhibiting and depressing the development of a parasite. Until recent times, plant resistance to the root-knot nematode was being explained by the structural characteristics of roots preventing larvae from penetrating into the plant. Frequently, reference is made (Filip'ev, 1934, and others) to be unpublished work of Arzberger who indicates that the roots of unsusceptible varieties of cow-peas have more protective tissue than susceptible varieties; their cork layer is better developed and has fewer ruptured sections. This theory of mechanical barrier was pursued also by Korab and Butovskii (1939) in explaining the action of plants antagonistic to the beet nematode: "By stimulating the passing of nematode larvae from the cyst into the soil, they (the plants) attract them to themselves en masse, but keep the larvae from entering their roots, as a result of which they perish from exhaustion in the futile attempts to penetrate the tissue of the roots they were attacking".

The humoral reactions of the plant to the nematode within the root was ascribed of little importance until lately. It is true that Kostoff and Kendal, investigating nematode galls on tobacco, back in 1930, expressed the hypothesis, that the plant fights nematodes by isolating antibodies, namely precipitins, lysins and agglutinins; however, the protection role of these anti-bodies was not clear, since both, galls and nematodes develop on tobacco very well. Only in 1939 did Barrons (1939) come forward with the assertion that larvae of the root-knot nematode penetrate susceptible plants and sturdy plants in the same ease, but do not develop in the latter. The author sees the reason for this in the action exerted by sturdy plants on larvae, namely by their isolation of antibodies neutralizing the ferments of the alimentary glands of nematodes. Barrons' viewpoint was met with approval; the production of antibodies by plants served to explain also the resistance of some potato varieties to the potato nematode (Gemmell, 1943).

Immunity, however, need not necessarily depend on the isolation of antibodies, but may be due to the structure of internal plant tissues; structural characteristics, namely the roughness of cells of the meristematic area in the stem node served to explain the non-susceptibility of some wheats to isosomes [izozomy]* (Phillips and Dicke, 1935). [Begin p. 439] The plant may be saved from infestation also by the quick tempo of its development: according to observations conducted by Chailakhian (1947), this was the reason why hemp grown on a short day escaped infection by broom-rape.

Our immunity investigations began with observations of cotton. Its inspection was given much attention, and cotton proved to be very resistant to the root-knot nematode. In Sukhumi, on a sector severely infested at the time of cotton planting, no galls were found on cotton roots at the end of the season. However, in a systematic investigation of the roots, beginning with the day of invasion, it was found that infestation had occurred, but that later the larvae had perished.

* [Probably isosome-galls]

Observations of cotton were conducted in several series of experiments and always with the same results: during the first week following invasion, galls harboring larvae already in the phase of parasitism appeared on the roots — thick, with a powerful bulbus and immotile. Then the gradual destruction of larvae began; in two weeks a large part of larvae was dead, and the galls began to disappear. Yet some larvae do complete development and begin to molt. No larva succeeded in completing development up to conversion into a female: they all died during metamorphosis. Nonetheless, there were individual cases when males appeared. During an investigation of nematodes by the tens in cotton roots, three developed males were found living there. Their measurements were dwarf-like: (1) body length 850 units*. width - 26 units*; (2) length - 850 units*, width - 28 units*, and (3) length - 1100 units*, width - 27 units*. A study of the galls showed that they developed on account of the increased size of rind parenchymal cells which reached 90-100 units* in the galls, yet on the same roots above and below the galls - 40 units*, i.e., assuming that their form is cubical, the size of the cells had increased by approximately 13 times. The central cylinder of the root also thickens, but to a lesser degree. In some cells of the central cylinder considerable granularity is visible, which according to Kostoff and Kendal, serves as an indicator of occurring immunological reactions. We were, however, unable to find any giant cells. We believe starvation to be responsible for the dying of larvae: larvae are incapable of causing the formation of giant cells, source of their nutrition, and although some larvae continue to subsist for a while and even reach maturity, they cannot accumulate the supply of food needed to complete metamorphosis, and inevitably perish during molting. Males, which require less food, develop in individual cases, but do not attain their normal dimensions.

Observing parasite fate in other resistant plants, we found that it was similar to that in cotton. In testing resistant South American tobacco — Nicotiana glauca Schk., invasion of roots was achieved easily. Small galls appeared on roots as a result of feeding the secretion of larvae. Larvae began to develop, but subsequently all died, and the galls resolved. Not even males could be obtained on this plant, all larvae died before molting. A similar picture was obtained in infestation of the sturdier varieties of sweet potatoes, with the only difference that individual larvae did complete their development in these sweet potatoes and were transformed into mature females. However, a large majority of the larvae which had invaded the plants died before their development was completed. Citrus plants never suffer from heteroderosis, but infestation of young roots in strongly invaded soil occurs rapidly. [Begin p. 440] Small roots invaded by a large amount of larvae cease growing and assume a club-shaped appearance. Rind parenchymal cells swell up to 70-80 units*, while their dimensions outside the gall do not exceed 20-30 units*, i.e. cell dimensions increase by 20 times. Giant cells do not form; the larvae thicken somewhat and assume the appearance of parasitic phases, but they soon perish. The disease ends in citrus even quicker than in cotton. Nematodes infiltrate just as easily the roots of crotalaria, but they never finish their development within the plant and, thanks to its resistance to the root-knot nematode, this plant is being recommended increasingly for anti-nematode crop-rotations.

We can see that the easily perceptible difference between susceptible and resistant plants rests in the circumstance that the plerome cells of the latter do not react to nematode excretions by forming giant cells. Reaction of the

* micron

rind parenchyma cells of resistant plants is, however, no less than that of the cells of plants most susceptible to the root-knot nematode. It has also been observed that in resistant plants, larvae secretions depress fission of meristem cells leading to temporary growth interruption in small roots.

Infection of maize is not always successful; regardless of strong soil invasion, larvae frequently fail to infiltrate roots; yet in other cases, especially in flower pots, the invasion of maize is almost as successful as that of susceptible plants. At first, the penetrated larvae cause swelling of parenchyma cells increasing their dimensions by approximately 5-6 times, afterward there develop giant cells with many nuclei in the center. Thus originates a normal source of nutrition and larvae development can complete successfully. Observations show that in many cases maize resistance is due to the fact that larvae do not penetrate the roots. In trying to introduce larvae into the roots of some other cereals (such as <u>Cynodon dactylon</u> Pers.), we did not succeed even once, and Barrons' assertion that invasion larvae infiltrate resistant plants as easily as they do susceptible ones was not confirmed by our observations.

Whether or not the absence of infestation is due to the inability of larvae to surmount the barrier of protective surface tissues or to other reasons (for instance, absence of positive reaction in larvae to these plants) is not known.

The dimensions of females developed in resistant plants on which large galls failed to form are smaller than in strongly susceptible plants. In an investigation of the same garden female dimensions were found to be:

on squash: length - 1060 $\pm$ 150 units*; Width - 715 $\pm$ 76 units*;
on maize: length - 680 $\pm$ 95 units*; Width - 418 $\pm$ 81 units*;

Since a large part of the female body consists of egg tubes, there is no doubt that small females will hatch fewer eggs. The duration of development of parasite larvae in sturdy plants, in which development usually is not fully completed, is protracted already in the first stages. Yet, there was no difference in the duration of development of parasitic larva into a mature female, when plants of such varied susceptibility to the root-knot nematode as the cucumber, the tomato, peas, clover, lupine, vetch, nightshade and Acalypha were grown concurrently in the same containers.

In resuming our observations of plant immunity to the root-knot nematode, we shall, first of all, endeavor to classify the phenomena observed. There is no doubt that the protective reactions of plants to parasites are simpler than those in animals, [Begin p. 441] but, in relation to helminths, they can easily be adapted to the classification scheme provided by Soviet helminthologists for animals (Shul'ts and Shikhobalova, 1935).

To begin with, plant immunity will be natural or inherent. The phenomena was observed in cotton, in tobacco — <u>Nicotiana glauca</u> Schk., in citrus, sweet potatoes and, probably, intrinsic in many resistant plants, fit perfectly the concept of partial immunity characterized by the partial development of parasites and their subsequent destruction.

In less sturdy plants, such as maize, vetch and others is observed unsterilized [nesteril'nyi] immunity characterized by (1) less infestation, (2) smaller dimensions of developed helminths and (3) decrease in there fertility.

* micron

Sometimes in these plants parasitic development is also protracted.

Immunity of age is also observed: woody plants suffer badly from heterodererosis mainly at an early age. In the heavily nematode infested Sukhumi Botanical Garden, old tea plants were not affected, but the seedlings of tea were easily infested.

Naturally, the immune state of a plant is not unalterable, but it depends on many factors. In case the plants weaken, or, on the other hand, the parasites are reinforced as a result of extremely strong invasion of the soil, galls will form also on highly resistant plants. The phenomenon is analogous with that observed in animal helminthiasis: weakening of the host reduces its resistance to invasion of intestinal worms. However, plants particularly susceptible to the root-knot nematode, such as tomatoes, cucumbers and others, are infested by it under all growth conditions, even under the best, such as are provided for vegetable plants in hothouses and in industrial gardens.

In plant immunity to the root-knot nematode, the phenomena of group immunity have been observed: the same legume varieties are resistant to the nematode and to fusarium, American grape is more resistant to the root-knot nematode than European grape; the same plant is resistant also to Phylloxera. In a study conducted in the USA of the resistance of 17 domestic and 14 foreign cotton varieties to Fusarium vasinfectum and to the root-knot nematode, resistance to both parasites varied in the same direction (Miles, 1939). The parasites indicated have the common characteristic of infesting the root during the same phase, namely the early phase of antogenetic development, hence the characteristics of this phase will exert influence on all of these parasites: thus, the rapid tempo of development of the root and the quick hardening of its tissues will be unfavorable for each of them.

Mechnikov, back in 1892, defined the infection as a struggle between two organisms. The nematode means of attack is a chemical weapon, — excretions of its esophageal glands; possibly, the protective means of the plant are also chemical — antibodies neutralizing these excretions and preventing the development of giant cells, source of nematode nutrition. The presence of antibodies has not been ascertained, however, as per analogy with the protective reactions of animals to the introduction of helminths in them, it is entirely probable. The hypothesis of antibodies is, however, hard to reconcile with the fact that only the action of secretions — formation of giant cells — is depressed, while the rest (depression of meristem cells and hypertrophy of the cells of rind parenchyma) appear very obviously. Therefore, it seems more probable that resistance depends on the characteristics of pleromo cells, namely on the low reactivity of these cells to secretions of the root-knot nematode. Reduced reactivity may be due to the fact [Begin p. 442] that pleromo cells of resistant plants pass rapidly through those early stages of their development in which they are capable of turning into giant cells. The rapid development of roots renders these plants resistant to all diseases infecting roots in the early stages of their ontogenetic development.

HOST PLANTS OF THE ROOT-KNOT NEMATODE. Number and systematic position of hosts. By virtue of the extremely wide range of hosts, the root-knot nematode belongs to eurytrophic [evritrofnym] parasites; the number of plants on which it is registered is vast and keeps increasing. To illustrate the above, a course of study of hosts is shown in table 6.

TABLE 6

Chronological record of hosts of the root-knot nematode

Author and title	Year of Publication	Number of hosts indicated	Material used in compiling list
Muller. Monograph on the root-knot nematode	1884	36	On plant from Brazil, the rest from Europe
Frank. Monograph on the root-knot nematode	1885	50	Same
Neal. Monograph on the root-knot nematode	1889	64	Florida, USA
Marcinowski. Abstract on the plant parasitic nematodes	1909	235	Abstracts from literature
Bessey. Monograph on the root-knot nematode	1911	480	Same
List of British Imperial Bureau	1931	569	"
Goodey. Abstract on plant parasitic nematode	1933	621	"
List of the US Department of Agriculture (compiled by Buhrer, cooper and Steiner)	1933	855	Abstracts from literature and material of the Department of Agriculture
First addition to preceding list (compiled by Buhrer)	1938	+477	Same
Second addition (compiled by Buhrer)	1940	+ 55	"

Thus, we can see that by the year 1941 the number of known root-knot nematode hosts had increased to 1387 plant species and subspecies. It must be noted, however, that not all designations are authentic; part of the plants registered, probably, possess partial immunity and should not be considered as host of the root-knot nematode. Not once was root-knot nematode infestation registered on spore plants [sporovye rasteniia], but among flowering plants infestation was found in representatives of angiospermae as well as in those of gymnospermae; in the latter, by the way, very rarely: there are descriptions of infestation of the ginkgo tree, juniper and the palm (Cycas).

Of the 280 families into which angiospermae are usually broken down, infestation by the root-knot nematode is known among representatives of 125 families, or 44% of their total number. [Begin p. 443] In some families, the number of species on which the nematode is found constitutes 100%, yet in others it is but fractions of one percent of the species belonging to a family. The families among whose representatives infestation is not known include the parasitic and aquatic ones which cannot be infested due to their ecological characteristics, and also little distributed groups which, probably, hardly ever are found on cultural fields infested by the nematode.

In the USSR, in one year's work, notably 1935, conducted on a large scale by the External and Internal Plant Quarantine Department of the Ministry of Agriculture, USSR, 241 forage plants were registered as hosts of the root-knot nematode (Ustinov, 1939).

At present, after utilizing works on the root-knot nematode published since that time — accounts of quarantine laboratories for the years 1936 and 1937, materials of the Laboratory of Lower Worms of the Zoological Institute, Academy of Sciences USSR, the author's observations in Abkhazia — we have increased the list of known hosts to 358 species. The host plants registered in the USSR belong to 74 families, making up 59% of all those families whose representatives include hosts of the root-knot nematode known in world literature. This great variety in the systematic position can be explained by the fact that gardens and greenhouses were investigated, the reason for the many introduced plants among the hosts.

Families are arranged in the order of host abundance:

1.	Compositae -	45 species	7.	Rose family -	12 species
2.	Legumes -	36 "	8.	Goosefoot family-	10 "
3.	Nightshade -	20 "	9.	Cereals -	10 "
4.	Mint family -	18 "	10.	Carrot family -	9 "
5.	Mustard family -	15 "	11.	Willow family -	9 "
6.	Olive family -	13 "	12.	Mallow family -	9 "

Naturally, these figures do not characterize the degree of infestation of the individual family, since the number of species within the family varies greatly. The root-knot nematode is less important to compositae than to some other families, and the large number of hosts registered in this family can be explained by the wide distribution of its representatives. This applies even more to cereals on which the nematode is a rare parasite. Yet to the gourd family, in view of its smallness, this parasite is very important, even though only 7 nematode hosts have been registered among them.

Thanks to the cooperation of many institutions in the work on the root-knot nematode, its hosts in the USSR have been investigated in a short time much better than those in a number of other countries, which is quite obvious from a comparison of the list of hosts compiled by us with the lists of other countries, and warmer countries at that. Thus, only 32 plant species have been designated for the Philippines (Fajardo and Palo, 1933); Southern Rhodesia - 108 (Jack, 1943); Hawaii - 122 (Parris, 1940); Japan - 41 (Hagakura, 1930); Southern China (Canton vicinity) - 26 species (Li and Ley, 1938). The number of known hosts in northern countries is not at all large: only 8 species of plants are cited for Canada (Crowell and Lavallee, 1942).

The largest number of hosts is known in Turkmen — 190 species, next in Western Gruzia — 136 plant species. In Azerbaidzhan, 73 host plants are registered; in accounts of the Quarantine Laboratory, on 9 plants were indicated for Uzbekistan, but Brodskii and Zemliańskaia (1946) have already found the root-knot nematode on 52 plants. [Begin p. 444] The number of host plants known for the RSFSR is 74; for the Ukraine — 46; White Russia — 5; Kazakh SSR — 14, and separate instances in some of the other republics of the Union.

SUSCEPTIBLE AND RESISTANT PLANTS. Having familiarized oneself with the long list of hosts of the root-knot nematode, it would be wrong to conclude that biologically all of these hosts have equal significance for it; on the contrary, to some plants the nematode is the most significant parasite, yet to others it is an infrequent and unimportant one. The families more susceptible to the root-knot nematode include nightshade, goard, and legumes, although the last of these families has many resistant species and varieties. Among other families, strong infestation is known in some [species] of the carrot family, compasitae, morning glory, and the goosefoot family. Those infested worse than others among woody plants are the representatives of Moraceae, of the willow family, the peach of the rose family, pomogranate of the pomegranate family and the tropical Rubiaceae — coffee and quinine trees.

Those resistant to the root-knot nematode among annual cultivated plants are cereals. There are no indications in world literature as to the importance of infestations to cereals or herbaceous plants, but the number of representatives of this family registered as hosts of the root-knot nematode is rather considerable. In addition, some species and varieties of legumes are resistant: they are of the greatest importance in the struggle with the nematode. Resistant are also a large part of the European fruit plants, with the exception of the peach and the plum. Plants among subtropical fruits which do not suffer from the heteroderosis are citrus, avacado and feijoa.

BIOLOGICAL FORMS OF THE ROOT-KNOT NEMATODE. The developmental course of parasitism usually leads from polyphagia to monophagia. Many eurytrophic nematodes — plant parasites, as well as plant parasitic insects form nutritively specialized races which frequently constitute the first stage in the formation of a species. The best nematode — *Heterodera schachtii* Schmidt was until recently considered as one species with several races, but now this species is being broken down into 5 distinct species. Another eurytrophic plant parasite — the stem nematode — *Ditylenchus dipsaci* (Kuehn) Filipjev is also a complex species including 7 different forms, part of which, probably, will also prove to be a distinct species. In animals entering into so close an interrelation with plants as those producing galls, specialization is particularly strong.

These deliberations prompted many investigators, beginning with Frank (1885), to search for forms of the root-knot nematode specialized in nutrition; they all, however, obtained negative results. Invasion from one plant to a series of other plants occurs very easily under field as well as under laboratory conditions, even if the latter plants were separated very far systematically. There can be no doubt that a considerable part of the root-knot nematode population is extremely eurytrophic and can develop on a large number of different plant varieties. This, however, does not exclude the possibility of their coexistance with specialized races developing on but a limited number of hosts. [Begin p. 445]

Plants especially susceptible are infested by all populations of the root-knot nematode, and no instance of an unsuccessful infestation of these plants by any viable invasion material, taken from any plant whatever, has been noted.

Sturdy plants, however, become infested by some populations and not by others. Thus, according to Christie and Albin (1914), in the USA, in testing 9 populations of the root-knot nematode on clover - Trifolium resupinatum L., the plant proved susceptible to 4 populations, produced indefinite results in the case of one, and was resistant to the other four populations. These observations served the authors as a basis for their assertion that the root-knot nematode includes specialized races. The second tests conducted by these authors with 14 nematode populations on 10 different plants also showed varied susceptibility of sturdy plants to different populations of the root-knot nematode and, in the authors' opinion, at least 5 different forms can be isolated from the populations tested.

To verify these observations, we grew resistant plants in flower pots in soil dehelminthized by drying in the sun, and then infested these plants with different nematode populations; by the word "populations" we mean invasion larvae taken from one plant specimen, although from different oothecae. In the course of the season, cotton was infested many times with populations taken from cucumbers, tomatoes, tobacco, balm mint, acalypha and, in the capacity of a particularly aggressive population, with oothecae developed on maize under natural conditions, in so doing, invasion material was taken from different plant specimens grown in different places. Experiments with all populations produced identical results: invasion larvae easily infiltrated roots, began to develop there causing small galls, but died subsequently, because they were unable to form giant cells. Identical results were obtained also with clover: all populations infested the plant successfully, completed there their development, and females began to hatch eggs. No variations were noted in the developmental tempo of the different populations.

Invasion of maize, on the contrary, produced quite different results. In many cases, we were entirely unable to infest it; in some cases infestation occurred easily and sometimes even to a considerable degree. Of the populations tested, taken from balm mint, acalypha and tomatoes, only those taken from tomatoes infested maize. This recurred in two series of experiments conducted consecutively with different maize varieties and with populations taken from plants of different places.

Can a conclusion be drawn from these experiments as to the actual existance of different "races" of the root-knot nematode, with only a few of them being able to infest maize? We believe that it cannot be done and that the difference in invasion results is due rather to a varying activity and viability of invasion larvae. A seasonal variation has been observed in the resistance of maize; in the spring its infestation is unsuccessful, but at the end of summer it proceeds successfully. In 1946, maize grown on a sector near the farm was not infested by the nematode (with very rare exceptions), but at the end of summer it was easily infested by soil taken from this sector and containing larvae developed chiefly on tomatoes and eggplant. Soil taken from another, very small garden in Sukhumi at the end of summer resulted in invasion almost equally of maize and of cucumbers: 402 galls developed on the cucumbers planted on 2000^{3}cm of this soil, and on maize 323 galls. Yet, in the spring this soil failed to infest maize growing in flower pots, and among the few maize plants growing in the little garden, only one was slightly infested by the root-knot nematode. [Begin p. 446]

It is natural to presume that the seasonal variations in infestation are due to the big difference in the number of invasion larvae prevalent in the soil: if, in the fall, their number was upward of 200 specimens on 1000 cm^3, then in the spring there could be only single specimens. In the spring, invasion capacity of larvae which had been starving since fall must also be much lower than in those freshly emerged. All invasion material used to infest maize in pots was fresh, nonetheless, the maize was infested only by the populations taken from tomatoes. One must assume that larvae which develop on tomatoes are more viable and more aggressive than those on balm mint and acalypha, for larvae developed from eggs of large females on susceptible plants are larger than larvae developed from the eggs of small females on more resistant plants. As per our measurements, the average size of invasion larvae from the oothecae of large females was 429 ± 14 units*, and from the oothecae of small ones — 414 ± 14 units* (upon measuring 122 specimens of each group).

An interesting phenomenon is the difference in the susceptibility of cotton to the root-knot nematode in the USSR where cotton is resistant, and in the USA where the nematode is considered a serious parasite of this crop. Has, there really developed a specialized nematode race, or does the matter concern the host and not the parasite? It is known that cotton represents a complex of diverse forms. A similar diversity is observed also in plums: in the USSR they do not become infested by the root-knot nematode, but in the USA they frequently are affected by heteroderosis. Such differences in susceptibility in the same plant varieties are, however, very few; in the large majority of cases, references to plants susceptible or resistant to the root-knot nematode are identical in all countries throughout the world. It is true also that different populations did not succeed in causing certain types of galls infested plants; in a case of slight invasion galls developed only sparsely in a case of strong invasion — galls were large and numerous, regardless of the populations we used to infest a plant. Thus, up to now, we have been unable to establish the existence of forms of root-knot nematode that possess a specificity with respect to nutrition. There is no evidence that the differences in invasion capacity are fixed hereditary characteristics of some populations, and there is no doubt that in a series of cases these differences are conditioned by changes occurring in the physiological condition — age and viability — of larvae and in the condition of plants.

The exclusive polyphagia of the root-knot nematode prompts the hypothesis that its evolution did not progress in the direction of increasing specialization of the parasite in relation to its hosts, but in the direction of a decreasing specialization, and that the root-knot nematode acquired the ability to infest plants extremely diverse systematically. It is, however, hardly probable that a species with so wide a realm of distribution and so large a number of hosts should represent something homogenous; it is, however, much more difficult to establish races among root-knot nematodes than among the other species of plant parasitic nematodes.

* micron

"Novoe v urhenii o gallovoi nematode"

[NEW IN THE STUDY OF THE GALL NEMATODE]

A. A. Ustinov

pp. 446-452.

CONTROL MEASURES AGAINST THE ROOT-KNOT NEMATODE

There hardly exists another plant parasite against which so many control measures were tested as against the root-knot nematode. In foreign countries the bourgeois regime does not allow expansion of state measures and therefore the invasion of the fields by the nematode steadily increases. For example in Florida and California the cultivated [begin p. 447] fields are so severely infested by the root-knot nematode that only cultivation of plants resistant to it or ripening early is possible.

In the USSR a series of effective control measures are applied against the root-knot nematode.

Physical control measures

Among physical control measures the thermal ones are developed, first of all — partial sterilization of the soil with steam. The technical requirement is a sufficiently deep heating of the soil up to 60-65°C. This method is used in the U.S.A. for control of the root-knot nematode in greenhouse soil, but in other countries it has not spread; in open ground on a somewhat extensive scale it is not adapted anywhere. Various temperatures were suggested for heating of the soil; the most widely used for this purpose are sets of perforated pipes through which super-heated steam is led under high pressure from a steam boiler. Attempts were made to use boiling water instead of steam for the heating of the soil, but this is a less effective measure and requires an enormous amount of hot water — more than 800 liters per cubic meter of soil.

Hot water was suggested more than once for "dehelminthization" of living plants; in the Soviet Union corresponding experiments were conducted by Ikhtinskaia and Arkhangel'skaia (1939) for treatments of "levanda" [lavender ?], by Selivonchik (1938) and Ustinov (1938). Warm baths were arranged in a barrel into which a pail was dropped. Into both containers was poured water of equal temperature and during the work very little hot water had to be added into the inner container in order to maintain needed temperature. Before dehelminthization the plants were kept for 30 - 40 minutes in warm water at 42°C, than they were immersed in the bath and after the bath immediately cooled in cold water. A 50° temperature was effective when the exposure was considerable (at least 15 minutes). According to our experiments the most suitable method is the immersion of roots in a bath for 5 - 10 minutes at a 51 - 53° temperature; but not all the plants can stand this treatment.

Heat dehelminthization of plants in the control of the gall nematode cannot be standardized in the same measure as was possible in the control of the stem nematode in hyacinth bulbs. The assortment of plants affected by the root-knot nematode is very large and their tolerance of heat varies, and many of them can endure it considerably less well than the hyacinth bulbs. It is very difficult to adjust the temperature such that the nematodes would be killed and the plants would not be harmed. Therefore this measure did not become part of established practice either as means of quarantine or treatment.

Chemical control measures

An enormous number of chemical substances were tested against the root-knot nematode. Attempts were made to introduce "OV" [according to Callaham: abbrev. "otravliaiushchie veshchestva" — toxic agents, i.e. fumigants] into the soil for treatment of infected plants, but they were not successful; all the fumigants are poisonous for plants and can be applied only for the treatment of the soil before planting. Soil fumigation presents considerable difficulties. The interaction which develops between the fumigants and the soil changes the effectiveness [begin p. 448] of fumigation in various soils (Chigarev, 1936). A considerable portion of the chemicals are not available for fumigation, being adsorbed by soil particles, and some of the fumigant evaporates; therefore the amount of poison used for soil fumigation should be hundreds of times larger than for surface treatment. Carrying out of fumigation is more successful in warm (but not hot) weather (about 20°C); the soil has to be well cultivated and relatively dry, because the greater part of the fumigant does not penetrate moist soil. The poison should be introduced into the soil in large amounts at 25 cm intervals; in small areas the work can be carried out with the help of an injector or under a shovel; for the treatment of large areas apparatuses are constructed which are attached to plows. When powdered substances are used, it is better to distribute them all over the plot [continuously] cultivating the earth so that the poison will be beneath a layer of earth. For successful fumigation, immediately after introducing the chemicals the soil has to be covered — this is a necessary condition for the effectiveness of fumigation. A certain substitute of covering can be achieved by watering the soil from the surface, which also inhibits evaporation of fumigant. The surplus of chemical substances is toxic for plants; therefore after removing the cover, and 10 - 15 days are required for airing of the soil before planting. The majority of fumigants have a favorable effect on the growth of plants increasing the amount of nitrogen substances in the soil.

As a rule no substance exterminates completely the nematodes in the soil, but only reduces the population to an economically unnoticeable level. A negative characteristic of fumigation is that it destroys also natural enemies of nematodes. It is pointed out that a valuable characteristic of fumigants is that the majority of them are not only poisonous for animals but are also fungicidal. And this means that they kill not only the devouring pre-parasitic larvae of predators but also the fungi parasitizing nematodes and thus considerably reduce the number of their enemies. It is understandable that this makes it easier for the surviving specimens to rebuild the population. The results of experiments with the control of root-knot nematode conducted in the USSR were already published (Ustinov, 1934, 1939). After the publication of these works, the treatment of soil with "tsianplav" [? cyan-fusion ?] was tested. At a dose of 100 g. per 1 m^3 (1 ton per 1 hectare) in a sandy soil the "tsianplav" [?] produced a noticeable nematocidal effect by reducing the contamination of plants in cultivated plots on the average 1-1/2 times as compared with control plots; nevertheless about 30% of the plants in treated plots were infested by the nematode.

In order to compare the effectiveness of various control measures it is necessary to give a numerical evaluation of the degree of infestation of the field plot with root-knot nematode; and for that purpose the infestation index of the given plot has to be calculated. We determined the index in the following manner: the plants in the plot were pulled out and examined thoroughly; if the plot was small — all the plants were examined, in case of a larger field section — every fifth or tenth plant. The most precise method for the evaluation of the infestation of individual plants is the tabulation of all the galls on their roots. But even this method cannot produce entirely precise results because the galls can be of very different sizes; in order somewhat to reduce these differences it has been accepted to count each 2 mm (lengthwise) of large galls for one gall. However when the thickness of the gall is considerable, in 2 mm of its length there are many nematodes so that such a section equals not one but many individual galls. It is necessary to limit field work to an approximate evaluation of the degree of damage [begin p. 449] of the roots expressing it in units. Adding the units and dividing the sum by the number of plants checked, the mean level of infection of one plant in the plot is obtained. Multiplying this by the percent of affected plants and dividing the product obtained by 100, the index of infestation of the plot is calculated. Comparison of indexes of various plots made it possible to express the effectiveness of measure in percentage. The most effective of the now known nematocides is chloropicrin. In comparing the results which we obtained from the use of this fumigant with data from literature, it can be seen that for the heavy and moist soils of Abkhaziia larger dosages of chloropicrin are required than those recommended in the U.S.A. There, 25 to 50 g. per 1 m^2 dosages are usual while in our experiments the 25 g. dosage produced a weak effect; a 50 g. dosage (which equals 500 kg. per hectare) reduced 4 times the infestation in comparison with the control and freed the plants for one year from a serious invasion. Only very high dosages of 100 g. per 1 m^2 produce a considerable effect reducing the infestation more than 20 times.

Ethylene-dichloride and methyl-bromide were suggested as fumigants which are cheaper than chloropicrin. Both substances are toxic to humans and the former is, besides, inflammable and explosive. American publications recommend for ethylene-dichloride a dosage of 15 cm^3 and for methyl-bromide — 40 g. per 1 m^2 of soil. There are no reports yet on tests in the USSR of these substances against the root-knot nematode. Apparently the ester of dimethyl-dithio-carbamic acids synthesized in our Scientific Institute for Fertilizers and Insecto-fungicides represent nematocides with greater promise; they are produced as a dust (with kaolin) and are powder-like substances which do not require the use of a gas mask; according to preliminary experiments in 1948 they cause a considerable decrease in soil infestation. DDT and hexachlorane appeared to be ineffective in the control of the root-knot nematode.

Progress in chemistry promises discovery of new fumigants which will make the cultivation of soil a less expensive measure; nevertheless it is hard to see how soil fumigation can be so attainable that it will be possible to use it on a large scale in the field. So far the chemical method is being used only in a covered [enclosed ?] ground. Soil treatment with chloropicrin was successfully applied in the control of the root-knot nematode in 1935 in vegetable hothouses of the sovkhoz "Chervoni Zori" in Khar'kov.

Agrotechnical control measures

The difficulty of control of the root-knot nematode by the chemical method compelled already the first researchers to emphasize control with the help of resistant plants. Resistant plants in a suitable crop rotation are the most practicable and often the only possible method of root-knot nematode control in the field in relatively large areas. Other agrotechnical measures such as fertilizers, dates of planting, clean fallow, as well as "lovchie"[?] plantings and flooding or drying out of the soil, are of lesser importance and in majority of cases are only auxiliary measures.

Data on plant resistance to root-knot nematode are scattered in very many works published in most diverse publications. In Russian language most of the material is gathered [begin p. 450] in the collection published by the All-Union Institute of Plant Protection "Collection of articles on nematodes of agricultural plants", edited by E. S. Kir'ianova (Sel'khozgiz, 1939).

The problem of the cause of resistance was brought up only rarely (Klechetov, 1947). Foreign papers, mostly short notes frequently in form of letters, are limited to simple statements of instances of resistance, without efforts at their explanation and theoretical basis. And also the foreign authors quite incorrectly consider the plant resistance to root-knot nematode as an unchanging static property of the given variety which does not depend on the plant's growth conditions, stage of its development and state. Therefore the data from different authors on resistance and susceptibility of plants frequently contradict each other.

The most important task is the further study of immunity and the establishing which resistance factors — anti-bodies or a rapid root-development — are of greatest significance. Under unfavorable conditions of development the resistance is lower and sometimes highly resistant plants are affected by the nematode as, for example, the peanut, a considerable infestation of which was observed in the Kazakhstan and Uzbekistan; even more frequently corn loses its resistance. It is true that not all the observations of infestation of resistant plants are reliable, because susceptibility is sometimes mistakenly registered according to the presence in the roots of only larval stages of the nematode and we know, that larvae penetrate resistant plants and begin to develop there, causing thickening of roots.

Anti-nematode crop rotations are built chiefly of resistant species and varieties of legumes and of cereals as well as grasses. Susceptible plants should be planted in contaminated soil after a 2-3 year interval. The influence of a change of crops on the root-knot nematode was followed up at the Abkhaziia zonal tobacco experimental station. Records taken in experiments preceded with tobacco showed that even a one-year cultivation of resistant plants greatly reduces the damage to plants (Ustinov, 1934). Study of soil infestation with invading larvae confirmed it: on plant-indicators planted in 900 cm^3 of soil from the tobacco field 976 galls developed and from the adjoining corn field — only 5 galls. The Department of Field Industry of the station developed for Abkhariia's tobacco farms a six-field crop rotation with the following order of crops:

1st year - Wheat and perennial grasses (red clover and rye grass);
2nd " - perennial grasses of second year of use;
3rd " - tobacco over a layer of perennial grasses, in the fall white lupine over green fertilizer;
4th " - corn over green fertilizer, in the fall vetch-oats mixture for hay;
5th " - tobacco over stubble, in the fall peas with rye for hay;
6th " - corn over stubble, in the fall sowing of wheat with perennial grasses.

The experimental crop rotation was conducted in a plot infested with root-knot nematode and with its introduction the root-knot nematode ceased to multiply in mass and did not cause severe reduction of tobacco yield.

In another plot of the same experimental station in 1935 71 - 95% of tobacco was affected with root-knot nematode and damage to the plants was so severe that a further planting of tobacco had to be stopped. The plot was occupied partly with cabbage and sugar sorghum and remained partly unused. By 1938 the soil infestation was so much reduced [begin p. 451] that of the plant-indicators planted here only a few were slightly affected by the root-knot nematode. The grass field crop rotation which are being introduced now due to the resolution of the Party and the government, have to be effective both prophylactically as well as a treatment against the root-knot nematode, especially when cereal grasses and not legumes are introduced. The vegetables are the ones which suffer mainly from the root-knot nematode in the Soviet Union; on vegetable farms it is also possible to control nematodes by way of crop rotation. On large farms crop rotation with introduction of perennial grasses is possible; in small workers' and home gardens the earth has to be planted every year with vegetables, but it is necessary to alternate the planting of more susceptible plants with resistant ones. For the latter can be used onion, garlic, corn, cabbage and other members of the mustard family, spinach, sorel, Jerusalem artichoke (very resistant plant), in the South — resistant varieties of sweet potatoes.

In arid and hot areas nematocidal effect is produced by clean fallow under the condition of several additional repeat plowings of the soil during the hottest period; Brodskii and Zemlianskaia (1946) checked the effectiveness of this measure in the vicinity of Tashkent. Mineral and manure fertilizers reduce harvest losses caused by root-knot nematode, but they are not a control measure, with the exception of calcium cyanamide, large dosages of which (7 t. per 1 h.) decrease soil infestation. Green fertilizers are more effective than are the mineral ones, because they are a biological method of nematode control.

Biological control measures

Practice long ago demonstrated the effectiveness of biological control measures against the root-knot nematode. It is frequently recommended in order to reduce the harmfulness of the root-knot nematode to introduce into the soil around the trees fertilizers of straw, grass or other plant materials. The nematocidal action of this measure was explained by an improvement of conditions of tree growth or by the separation, during the decomposition of the introduced substance, of poisonous gases which destroy the nematodes. It has been only relatively recently found out that the effectiveness of plant residue is conditioned by the fact that they create favorable conditions for the development of a large number of parasites of the root-knot nematode. Korab and Butkovskii (1939) point out the harmfulness for the beet nematode of plowing under of sweet clover as a green fertilizer, explaining it by the fact that the rotten mass of sweet clover is harmful for the nematode. But the significance of sweet clover is hardly specific and probably the matter here is also in the development of nematode's enemies in abundant deteriorating organic matter. Our observations in the Abkhaziia tobacco experimental station demonstrated the favorable effect of "sideration" [enriching land by planting legume crop] on decontamination of plots infested with root-knot nematode. Particularly marked was the decontamination in the plot where the tobacco suffered also from soil erosion and was so damaged that it produced almost no yield. After a completed "sideration" (mainly with lupine) the tobacco yield was satisfactory and its infestation with nematode was very limited.

Outlines of control measures against the root-knot nematode

In greenhouses the control measures come down to removing and destroying roots of diseased plants and to destroying larvae of root-knot nematodes in the soil. This can be done by partial sterilization of the soil with steam, its treatment [begin p. 452] with fumigants and, in an extreme case, by replacing the contaminated earth with non-contaminated and by thorough cleaning and coating with lime of the walls, corners and bottom of the frames.

Of great importance are prophylactic measures against introduction of root-knot nematodes into the hothouses. The law of the Five-Year Plan specifies the development of hothouse farms in the vicinity of large cities which makes the problem of their protection against the nematode very real; foci of the latter were found in many points of the Soviet Union and probably by no means all of them were disclosed because the damage caused by the nematode under field conditions further north is negligible. But when brought into hothouses the nematode can become a most dangerous parasite and its control will be very costly.

The leading measures under field conditions are agrotechnical. The decisive factor for annual plants in the control of the root-knot nematode is the introduction of crop rotations preferably in combination with other measures: green fertilizers, introduction of inexpensive fumigants (for example calcium cyanamide) in arid areas-drying of the soil by way of additional re-plowings in the summer. In order to reduce the state of invasion of the soil, the roots of severely affected plants have to be removed from the field after harvesting and destroyed; it is particularly important and easily accomplished in vegetable gardens.

Methods for destruction of the nematode in growing perennial plants are not yet known. Higher resistance of particularly susceptible species and varieties can be achieved by way of their vegetative hybridization with more resistant varieties. Improved feeding of diseased plants by way of introducing fertilizers decreases the harmful effect of the nematode; planting between the trees of cover crops, resistant to the root-knot nematode or keeping the soil as a clean fallow reduces the state of invasion of the soil.

A radical decontaminating measure is the planting, in a seriously infested soil, of perennial plants resistant to Heterodera infestation. Such action was taken in a sovkhoz near Sukhumi: lavander which was in the process of destruction from "heteroderosis" was liquidated and the plot was occupied with Aurantiaceae. After a few years we could not find here any nematodes at all even though a small amount of them probably remained on weeds.

BIBLIOGRAPHY

The root-knot nematode belongs to the number of the most dangerous parasites of agricultural plants and therefore naturally attracted the attention of researchers in all the countries of the world. A limited number of writings on this subject are scattered in works of institutions of higher learning and zoological institutes of the Union's Academies of Science, in publications on plant protection etc. We do not yet have a periodical which would review these writings. An index of our country's literature on plant-eating nematodes for 1936 was published by E. S. Kir'ianova (1939); later writings on root-knot nematode are indicated below. Foreign literature on root-knot nematode is represented mainly by short notes and reports, most frequently on problems of nematode control, and they are scattered in most diverse publications. The last monograph on root-knot nematode (Bessey) was published in 1911 and is now only of historical significance. Bibliography of older (up to 1931) works on nematodes of the genus Heterodera was published by the English Imperial Bureau of Agricultural Parasitology (helminthology), 1931. Since 1932 and up to the present time the Imperial Bureau publishes a bibliographical journal "Helminthological Abstracts" which reviews the world literature on parasitic worms. From 1930-1933 the bureau published bibliographical handbooks on helminthology ("Bibliography of Helminthology") which became in 1934 part of the above-mentioned journal. [begin p. 453]

ARKHANGEL'SKII, P. P., 1937 -
The works of the quarantine inspection and the laboratory of the Narkomzem UzSSR during 1933-1937. (Results of investigation of the Uzbek SSR in regard to the root-knot nematode).
Sotsial. nauka i tekhnika, 10-11; 237-242

BEKLEMISHEV, V. N., 1945 -
On principles of comparative parasitology in application to blood-sucking arthropoda.
Meditsin. parasitologiia, 12(1):3-11

BLINOVSKII, K. V., 1945 -
The root-knot nematode (Heterodera marioni Cornu) - pest of tree species of Turkmeniia.
IZV. Turkmensk. filiala AN SSSR, 5-6, 107-113

BRODSKII, A. L. and ZEMLIANSKAIA, A. I., 1946 -
Biology of the root-knot nematode — Heterodera marioni Cornu and new ways for its control.
Tr. Sekt. zoolog. Inst. botan. i zoolog. AN Uzbeksk. SSR, 7-40.

VINNITSKII, I. M., 1946 -
Evolution of development cycles of nematodes of the Ascaridata order.
Izv. AN SSSR, ser. biolog. nauk. 4, 415-530

GILIAROV, N. S., 1939 -
Influence of soil conditions on the fauna of soil pests.
Pochvovedenie, 9, 121-137.

GORDEI, D., 1933 -
The root-knot nematode in Turkmeniia.
Biull. po kul't. sukhikh subtrop., no. 4(36) Stalinabad, p. 11-16.

GURVICH, G. A., 1935 -
Root nematode (Heterodera marioni Cornu, 1879) (Heterodera radicicola Greet, 1872) on crops of the eastern shore of the Black Sea.
Parasitolog. sborn. Zoolog. Inst. AN SSSR, No. 5, p. 317-337, fig. 1-15.

DOGIEL, V. A., 1941 -
Course in general parasitology.
Uchpedgiz. 1-287.

DUNIN, M. S., 1946 -
Immunogenesis and its practical use.
Tr. Sel'skokhoz. Akad. im Timiriazev, 4-, 147.

EGOROV, P. I., 1949 -
The root-knot nematode (Heterodera marioni Cornu) under the conditions of the Ukraine SSR.
Pratsi Odes'kogo Dersh. Univ., IV(57):99-121.

ZENKEVICH, L. A. (edit.) 1937 -
Class of round worms (nematodes).
Textbook in zoology, 1, 557-627.

IKHTINSKAIA, T. A. and ARKHANGEL'SKAIA, M. N., 1939 -
Results of work in the study of the root-knot nematode on "lavanda" [?] in the Crimea.
Sb. rabot po nematodam S-Kh. rastenii pod red. E. K. Kir'ianovoi.
Sel'khozgiz, 71-74.

KIR'IANOVA, E. S., 1939 -
Review of acquired knowledge on nematode diseases of plants in the USSR.
Sborn. rabot po nematodam S-Kh. rastenii.
Sel'khozgiz, 5-26.

KIR'IANOVA, E. S., 1949 -
The root-knot nematode and its control.
Ob'edin sessiia Sekts. Zashch. rast. VASKhNIL i Otd. biolog. i S-Kh. nauk. AN AzSSR (18th Plenum) Tezisy dokladov, 1. Baku, p. 29-33.

KORAB, I. I., 1949 -
The root-knot nematode and control measures against it.
Ob'edin. Sessiia Sektsii Zashchity rast. VASKhNIL i Otd. Biolog. i S-Kh. Nauk AN AzSSSR.

KOBAKHIDZE, D. N., 1941 -
Observations of root nematode under Tbilisi conditions.
Tr. Zool. Inst. AN Gruz. SSR.

KORAB, I. I. and BUTOVSKII, A. P., 1939 -
Principal results of study of beet nematode (Heterodera schachtii Schmidt) and of methods of its control.
Sb. rabot po nematodam S-Kh. rastenii pod red. E. S. Kir'ianova, Sel'khozgiz, 75-120.

KLECHETOV, A. N., 1947 -
Affection of roots of the rubber plant kok-saghyz with the root-knot nematode.
Izv. Kuibyshevski. S-Kh. inst. 9, 123-125.

LEVASHOV, M. M., 1932 -
Root-knot nematode in Abkhzaiia and on the shores of the Black Sea in North Caucasus.
Biull. VII Vses. S'ezda po zashchite rastenii, No. 5, p. 21.

LEVASHOV, M. M., 1935 -
Materials for the study of plant nematodes in Abkhaziia and on the shores of the Black Sea in North Caucasus, Parasitolog. sb. Zoolog. Inst. AN SSSR, no. 5, p. 301-315.

LITVINOVA, N. F., 1939a.
Root-knot nematode in the Kazakh SSR.
Sb. rabot po nematodam S-Kh. rastenii pod red. E. S. Kir'ianovoi, Sel'khozgiz, 65-70.

LITVINOVA, N. F., 1939b-
Harmfulness of root-knot nematode under Alma-ata conditions.
Izv. Kazakh. filiala AN SSSR , 1, 101-108.

MAKSIMOV, N. A., 1946 -
Growth substances, nature of their action and practical use.
Usp. Sovr. biologii, 22(2):162-180.

MIROVOI Agro-Klimaticheskii Spravochnik -
[World agro-climatic guide]. 1937.
Gidro meteorologicheskoe izdatel'stvo, 1-149.

PAVLOVSKII, E. N., 1945 -
Ecological tendency in parasitology. Zhurnal obshch, biolog. 6(2):65-92.

PAVLOVSKII, E. N., 1946 -
Handbook on parasitology of humans.
Izd. AN SSSR, 1, 1-521.

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Abstract and
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Agrokhimicheskii Analiz Pochv v
Laboratoriiakh MTS
[Agrochemical Analysis of Soils
in the Laboratories of MTS]

Izdatel'stvo Akademii Nauk SSSR;
Moskva, 1954, ~~v. 5, no. 5, 632-892~~

ABSTRACT

Introduction to above title states in part. "The non-black soil belt constitutes 30% of the territory of the USSR and about 50% of the European part of the Soviet Union.

"Among the soils widely distributed in the non-black soil belt are podzolized soils which form under coniferous mossy forests, peat-podzolized soils which develop under mixed grassy wooodlands, and gray woodland soils adapted to broadleaf forests.

"In the non-black soil belt, particularly in its northern part, are spread also podzolized gley soils and peat soils of lowland and upland bogs, fertile meadow soils develop in the river valleys of this zone.

"Podzolized soils cover the northern part of the non-black soil belt. It is characteristic for them to develop in the upperpart of their profele a whitish podzolic horizon deficient of organic matter and nutritive elements. The podzolic horizon always has an acid reaction, lacks structure, and is composed chiefly of a fine quartz powder. The magnitude of a podzolic horizon is varied and fluctuates from a few centimeters to 40-50 cm. Substances which are leached from a podzolic horizon store up lower in the alluvial horizon. The alluvial horizon usually has a brown coloring, a solid texture and a heavier mechanical composition than the podzolic horizon. It frequently possesses an acid reaction. The alluvial horizon gradually turns into maternal rock."

The author further discusses in detail thedifferences between podzolic soils and peat-podzolized soils, and technics and fertilizers required for their cultivation. Author explains importance of soil properties, nitrogen sources other than by introduction with fertilizers, role and availability of phosphorus, potassium and other nutritive elements essential to plant life. Methods for determination of natural content of above elements and of soil moisture appear to be described adequatel. Methods and procedures for analysis and formulas for mixing fertilizers are worked out, and required equipment is listed in the appendix.

Translator believes that booklet containe valuable material, finds text rather "scientific" and far from easy.

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K. V, Verigina

Agrokhimicheskii Analiz Pochv
v Laboratoriiakh MTS

Agrochemical Analysis of Soils
in the Laboratories of MTS

(For the non-black soil belts)

Izdatel 'stvo Akademii Nauk SSSR
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Trudy Zoologicheskogo Instituta v.9
No2 Collection of works on nematodes of
agricultural plants
Edited by E. S. Kir'ianova
Izdatel'stvo Akademii Nauk SSSR
Moskva 1951 Leningrad
p.513-553 410.9 L543

The Onion Nematode- Ditylenchus Allii (Beijerinck)

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The onion nematode or the stem nematode of onions- Ditylenchus allii (Beijerinck) is an onion pest of grave importance in a number of the European regions of the USSR. Thus, considerable decreases in onion yield were noticed in the District of Arzamas, Gorki Region in 1938-1940 and in the Penza and Kursk Regions in 1939. These decreases in yield were due to injuries caused by the onion nematode.

The work described here was conducted in 1939-1940 upon request of the Lenoblplan [Leningrad regional project] and the Gorki Regional Experimental Station for Field Husbandry. The war years delayed the publication of this work, but it is not outdated even at the present time.

Investigations were conducted in Laboratory for Lower Worms of the Zoological Institute, Academy of Sciences, USSR, in greenhouses, and on the experimental field of the Leningrad Regional Station for Plant Protection at Petrodvorets. Simular work was done at the village of Kichanzino on the experimental lot of the Arzamas base of the Gorki Regional Experimental Station for Field Husbandry. In addition, in the Arzamas area, material was collected in the following villages: Abramovo, Vozovatovo, Zabelino, Merlino, in Krasnoe Selo, and in Pushkarka where inspections were conducted on kolkhoz fields adjacent lots belonging to individual farm workers [Kolkhozniki]. In Leningrad and in Petrodvorets all observations and experiments were carried out directly by the author with the help of a laboratory worker, M. M. Grichoniuk, and temporary workers. The main place of work at Kichanzino was the experimental "nematode", base near the farm which consisted of two neighboring plots belonging to farm workers, and was treated as one plot. In previous years, the farmers had grown their onions without rotation of crops. Their onion yield dropped markedly, and in 1938 the entire onion crop was ruined on both lots due to its extremely strong infestation by the onion nematode. Then, upon request of the Arzamas base, the kolkhoz assigned the above-mentioned farmers adjacent lots at another place, and made their original allotments available to the experimental base. Thus, the Arzamas base acquired a lot for its investigations,

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measuring about 0.1 ha which was badly infested by the onion nematode. In the years of 1939-1940 a series of experiments was initiated on this lot for the purpose of making a study of the onion nematode and of discovering measures for its control. Our wishes concerning, primarily, the identification of forage plants susceptible to the onion nematode and the development of agrotechnics for its control, were taken into consideration when these experiments were begun. (Begin p. 513) As a rule, we checked field observation by microscopic analyses of which more than 10 thousand were made in Kichanzino and about as many in Leningrad.

Working Methods. To analyse infestation of whole plants as well as their parts, we used two methods: 1) examination of the more doubtful tissue section with binoculars and under a microscope in a drop of pure water on a slide or watch glass, or sometimes in Petri dishes. The infested plant tissues were then torn into the smallest possible bits with the aid of dissecting needles before or during the investigation process: 2) nematodes were extracted from the plants with the aid of pure raw water (water extraction of nematodes) as follows: the whole plant or a part of it was first cleared thoroughly of all soil particles stuck to it (expecially if the root system was to be analyzed), cut up into pieces of 2-3 cm in length, and placed in a glass of water or in a large supply jar [material'maia banka] depending on the amount to be analyzed. Then enough pure water was poured into the container, calculated to immerse the bulk of the plant. After 6-16 hours, depending on temperature conditions in the laboratory, the pieces of the plant were removed with pincers from the container, with the liquid left to settle for 30-60 minutes. During this process, the nematodes sank to the bottom. Then the top layer of the liquid was poured carefully, and the remaining liquid was poured into a Petri dish calculated to fill up one or two of its halves. The contents were examined with binoculars and the nematodes detected were taken from the water with a fine dissecting needle. In so doing, the needle was placed under the nematode body at its very center, perpendicularly to the longitudinal axis; the nematode was lifted to the surface of the liquid and removed similarly on fine needles. The point of the needle was immediately dipped in a drop of pure water on a slide where the nematode remained. The prepared compound was examined immediately under a microscope, at which time the nematodes, more often than not, were still alive. The above described change in the funnel [voronochnyi] method, used generally to extract nematodes from plants, simplifies the work and makes it more convenient.

The analysis of soil aimed at detecting the onion nematode was implemented by washing a specific bulk of soil through a sieve made of milling gauze No.18. About 1 kg of soil was taken from the layer under investigation and stirred thoroughly; then 25 cm of soil was separated for analysis and placed in a glass cylinder with an amount of water that exceeded the bulk of the soil by 5-10 times. After 3-4 hours, the well soaked soil blended thoroughly with the water, poured quickly into the sieve, and washed several times with fresh quantities of pure water. Then, the sediment was transferred to a Petri dish and examined, in part with binoculars. Nematodes were caught with a needle as in the preceding case. It is essential to note that there is no need to wash the entire soil specimen to be analyzed through a sieve, for then its precipitate would be so large that its examination would take a great deal of time and complicate the work. The procedure of washing, on the contrary, must be accomplished so as to retain in the sieve the smallest possible amount of soil sediment. The end result will even benefit from this procedure. A tall glass cylinder, about 40 cm in height should be used for this purpose and the soil should be stirred in water in this cylinder, for it provides quick rotary motion before draining.

As the liquid with the nematodes is poured into the sieve, large particles of soil will settle on the botton and on the walls of the cylinder, and thereby the sediment in the sieve will be considerably decreased after the rinsing. This will facilitate examination of the soil sample and will in no way impair accuracy of the analysis.

Composition of the onion - Allium Cepa L.-- On cultivated onions in the Arzamas area, we found 16 nematode species listed in table 1. Of these, the following four nematodes should be added to the list of injurious species: Aphelenchoides helophilus (de Man), Ditylenchus allii (Beijerinck), Pratylenchus pratensis (de Man), Rotylenchus multicinctus (Coob.). Apparently, in addition to these, the list of onion pests should include the half-parasitic nematode (Begin P. 514) Aphelenchus avenae Bastian, encountered frequently in plants in very large numbers under field as well as under storage conditions. Noteworthy among the nematodes cited in table 1, is also Eucephalobus elongatus de Man, which usually accompanies Aphelenchus avenae Bastian, especially when onions are infected by fusarium or gray mold. Both of these species are attracted in exceptionally large numbers. We shall restrict ourselves to this brief data concerning the specific composition of nematode fauna of the onion and shall report the results of investigations aimed at clarifying the biology of the onion nematode and at developing measures for its control.

Table 1.

List of nematodes found on onion plants in the Arzamas area

No. in consec. order	Name of nematodes	Parts of plant where found		
		Bulb	root	leaf
1	Acroboloides buetschlii (de Man)	+	+	+
2	Acroboloides sp.	+	+	+
3	Aphelenchoides helophilus (de Man)	+	+	+
4	Aphelenchoides sp.	+	+	+
5	Aphelenchus avenae Bastian.	+	+	+
6	Ditylenchus allii (Beijerinck)	+	+	+
7	D. allocotus (Steiner)	+	+	−
8	Pratylenchus pratensis (de Man)	+	+	−
9	Rotylenchus multicinctus (Coob)	+	+	−
10	Eucephalobus elongatus de Man	+	+	+
11	Cephalobus sp.	+	+	+
12	Diplogaster longicauda Claus	+	+	−
13	Diplogaster sp.	+	−	+
14	Dorylaimus sp.	+	−	
15	Paraphelenchus pseudoparietinus (Micoletzky)	+	−	+
16	Rhabditis sp.	+	+	−

History of study of onion nematode - Ditylenchus allii (Beijerinck)

The onion nematode was originally described by Beijerinck (1883) who had observed its infestation of the onion in Holland under the name of Tylenchus allii. We find it impossible to ascribe the honor of discovery of this species to Kuehn, as some authors (Newhall, 1932; Chitwood, 1940) have done it on the authority of the famous work by Ritzema-Bos (1888). The latter actually report that, in the years of 1877-1879, Kuehn had found trichina in onions and had described it as Tylenchus putrefaciens. This report had been published in the "Hallesche Zeitung" in 1878 or 1879. This issue, however, soon became unavailable, and Ritzema-Bos lost the opportunity to study this article. Hence, he writes in one of his own works that he must "also leave unsettled the question as to whether or not Tylench which Kuehn had found in a sick onion plant and had named Tylenchus putrefaciens n. sp. is identical with Tylenchus allii n. sp. described by Beijerinck, (begin P. 515) and in my investigation incorporated as Tylenchus devastarix Kuehn. I, however, still think that it is one and the same species." Hence, there is no basis for crediting Kuehn with the original description of the onion nematode, particularly since there are about 30 nematode species which can be found in the onion; some of which accumulate in bulb tissues in large numbers at all stages of development. Furthermore, Kuehn himself had given another name to the nematode he had found in the onion, so as to distinguish it from the stem nematode species established by him earlier - Anguillula dipsaci Kuehn--Anguillula devastatrix Kuehn--Anguillulina dipsaci (Kuehn) Goodey, 1932--Ditylenchus dipsaci (Kuehn) Filipjev, 1934. Our efforts to obtain the "Halesche Zeitung" proved futile. Thus, the identification of the onion nematode with Tylenchus putrefaciens described by Kuehn remains an open question, and justifies our belief that Beijerinck's description is the first, fully authentic description of the stem nematode of onions.

The species name of the stem nematode - Anguillulina dipsaci--Ditylonchus dipsaci, which up to now embraces the onion nematode or stem nematode of the onion, described by us, was established by Kuehn (1858) who had found the nematode in decaying grains from the heads of fuller's-teazel (Dipsacus fullonum Mill.). In a few years he, however, was forced to acknowledge that this name failed to imply the importance of the pest which caused also the well known stem disease of grain crops, including rye and oats, described by Schwerz as early as 1825, and an analogous serious disease of clover and other plants. Therefore Kuehn decided to change the original name to a more general one, and in 1868 he suggested naming the stem nematode Anguillula devastatrix (ravager) and he proved experimentally (1869) that it can pass from fuller's-teazel to rye. In subsequent years the stem disease was described to other crops. Nitschke (1868) described the stem disease of rye in Germany and named its causal agent Anguillula secalis. Prillieux (1881) described a disease of hyacinths in France caused by the nematode Tylenchus hyacinthi Prillieux.

Kuehn (1881) described a stem disease of alfalfa in Germany caused, in his opinion, by a particular nematode species - Tylenchus havensteinii Kuehn. Beijerinck (1883) described the above mentioned onion disease in Holland, the causal agent of which was named Tylenchuss allii. In the years 1887-1892, Ritzema-Bos published a series of reports in which he described the nematode disease of onions, hyacinths, rye, clover, alfalfa, buckwheat, and of mant other plants in Germany. He arrived at the conclusion that the causal agent of the widely spread stem disease of many crops was one and the same species - Tylenchu devastatrix (Kuehn), identical with the species causing similar diseases in different crops described by various authors. Thus, he believed that Anguillula dipsaci, A. devastatrix Kuehn, A. secalis Nitschke, Tylenchus putrefaciens Kuehn, T. hyacinthi Prillieux, T. havensteinii Kuehn, and also Tylenchus askenasyi extracted from moss (Buetschli, 1883) are synonymous with Tylenchus davastatrix (Kuehn). It seemed that the experiments of Ritzema-Bos fully confirmed his hypothesis concerning the identity of these nematodes. He infested onions with nematodes taken from hyacinths, and hyacinths with nematodes from onions. All of this justified the assumption that the stem nematode T. davastatrix (Kuehn) is the causal agent of disease in 34 plant species.

The opinion of Ritzema-Bos is generally accepted even at the present time but the species name suggested by him did not take root and was displaced by the name Ditylenchus dipsaci. The generic name had been changed earlier in connection with the work of Bastian (1865) (begin P. 516) who had established th genus Tylenchus, and upon suggestion of I.N. Filip'ev (1934), the name Ditylenchus was used instead. At the present time, the name of the stem nematode used most extensively is Anguillulina dipsaci (Kuehn) Goodey, 1932 and Ditylenchus dipsaci (Kuehn) Filipjev, 1934-1936. The list of hosts of this nematode includes more than 300 plant species, among them many cultivated plants; onions, oats, rye, maize, potatoes, beets, clover, alfalfa, and wild flora; chick-weed - Stellaria media Cyriel, bedstraw - Gallium aparine L., snowdrop - Galanthus nivalis L., bindweed - Convolvulus arvensis L., Sternbergia - Sternbergia lutea Ker.-Gawl., orache - Chenopodium album L., meadow grass - Poa annua L., couch grass - Agropyrum repens P.B., crowfoot - Ranunculus repens L. and so forth. The vastness of this group of hosts can be seen in the works of Schneider (1937) who discovered the nematode Tylenchus dipsaci var. tobaensis in the galls of pond weed - Potamogeton malayanus and parrotfeather - Myriophyllum spicatum in Southern Sumatra, and in the works of Zeller (1937) who found it in the same plants in the vicinity of Vienna. According to literary data, the stem nematode has a world-wide distribution and its hosts are not only surface plants, but also aquatic plants. On onions it lives in very many countries; besides Holland and Germany (Beijerinck, 1883; Ritzema-Bos, 1888), the nematode in found in France (Chatin, 1884), in England (Goodey, 1933), in America (Laidlaw and Price, 1910), and in Southern India (Barber, 1905). In recent times, Thorne (1945) segregated the potato stem nematode as a separate species - Ditylenchus destructor Thorne, 1945. In the USSR, the onion nematode was first mentioned by Fokin (1924) who, without seeing the nematode, attributed to an onion disease in Viatka (now Kirov). Onion injury by the stem nematode in the USSR attained full authenticity in 1935 when we received diseased bulbs from the "Gaint" sovkhoz in the Rostov Region and from the kolkhoz named for Kaganovich in the Penza Region. In 1936 we received bulbs infested by worms from the storage rooms of the Leningrad Fruit-Vegetable Marketing Enterprise [Lenplodoovoshchtorg] and from the Pella Station of the Leningrad Region. We noted with interest the very larg dimensions of the worms as compared with those from potato tubers. Investigation confirmed the fact that specimens of the stem nematode from potatoes of various geographical points are considerably smaller than those obtained from onions. This difference in dimension was observed in comparing adult specimens as well as in comparing larvae phases and eggs. In addition, permanent differences in the nematode were observed in the position of the vulva and in size alpha (relation of body length to its width). There existed obvious differences between the stem nematode of potatoes and that of onions; a report to this effect has been made (Kir'ianova, 1939). At that time, almost nothing was known about the biological differences between these nematodes, save Goodey's indications that in England, onions, wheat, barley, rye, oats, fodder, beets, turnips and peas grown on a lot infested by these pests, were not affected by the potato nematode race, although, as per his own remarks, this could have been due to insufficient infestation of the soil (Goodey, 1935). No one had undertaken a thorough study of the onion race, and it was, and by many still is, considered to be a parasite preying on various cultivated plants. The few authors (for instance, Steiner and Scott, 1934), who endeavored to subdivide the species Anguillulina dipsaci into several varieties, also listed the onion nematode together with many other forms under one variety A. dipsaci var. communis. (Begin P. 517)

Morphology. The onion nematode (table I, 1) is characterized by a well-proportioned thread-like body. On the average, adult specimens reach 1500 micron in length. The head and tail ends of the body are visibly narrowed down, with the tail ending in a point. The males are a little finer and considerably better proportioned than the females. Even Ritzema-Bos had noted that the worms from onions were visibly larger than those from rye and hyacinths, and he explained this fact by the abundance of nutritive substances contained in the bulbs. According to data by Ritzema-Bos, in Germany, males of the onion race are, on the average, 1510 micron in length and females - 1540 micron in length. Our measurements of nematodes from onion bulbs produced close figures (Table 2).

Table 2.

Dimensions of onion nematode Ditylenchus allii (Beijerinck, 1883) as per material from different places

Author	Material received from	Sex	Body length (in u)	Body width (in u)	Alpha	Beta	Gamma
Ritzema-Bos 1887	Germany	♀♀	1430-1730 (1540)		37-47 (41)		12-17.5
		♂♂	1430-1570 (1510)		41-50 (45)		14-16.5
Kir'ianova 1936	Pella Station, Leningrad Region	♀♀	1392-1680 (1525)	28-37 (30.7)	44.9-56.2 (49.8)	5.5-7.3 (7.1)	11.8-15.7 (14)
		♂♂	1392-1600 (1476)	20-25.7 (23.7)	54-78 (63)	6.1-9.3 (7.3)	13.9-17 (15.4)
Kir'ianova 1939-1940	Kichanzino village, Gorki Region	♀♀	1130-1924 (1440)	30-43 (34)	34.8-55.4 (42.5)	6.7-8.6 (7.6)	14-20 (16.7)
		♂♂	1190-1685 (1405)	20-30 (25.5)	44.8-74.2 (56)	6.2-8 (7.2)	14-18.6 (16)

Remark! Average sizes cited in parentheses.

The basic bulk of measurements was accomplished on specimens from the August generation. We found the largest female specimen (1924 u) in the September collection, and the smallest (1130 micron) - among worms gathered in July from shoots. Preliminary observations give the impression that the June and July generations have somewhat smaller dimensions compared with the August and September ones; this apparently can be explained by the difference in temperature. Regardless of fluctuation in dimensions, the onion nematode is relatively larger than the stem nematode of potatoes. Besides, it is distinguished by a shapelier body. In the onion nematode the proportion of body length to its width (alpha) is on the average over 40 in females and over 45 in males (Table 2); in the stem nematode of potatoes an average alpha equals 33 in females and 42 in males. The dimensions of larvae of the fourth age grown on onion are twice the size of larvae of the stem nematode of potatoes. In the onion nematode, the size of eggs, too, is larger. Having noted the large dimension of the onion variety, as compared with the dimensions of varieties obtained from rye and hacinths, Ritzema-Bos (1888) attached no importance to these differences. (Begin P. 518) He believed also that the races from rye, hyacinths and onions did not vary essentially as to bursa structure. He did, however, point out that in males grown on onions the bursa has somewhat smaller dimensions and that it is not as near to the tip of the tail as in those grown on rye and hyacinths, and that the bursa varies markedly in males obtained from different plants: it can extend to the very tip of the tail, completely encircle the tail, or reach only its center. We are unable to check Ritzema-Bos' data concerning bursa structure in the stem nematode of rye and hyacinths, but we can report that, according to our observations, in males of the onion nematode, the bursa in most cases, does not reach the tip of the tail by 27-42 micron, at a tail length of 75-90 micron, and encircles the tail wholly or comes close to its end only rarely.

The nematode body is covered by a thin, translucent, transversely streaked and exceedingly tight cuticle. At the center of the head end is situated the oral aperture encircled by 6 merged, and hence little noted, lips with 6 lip-nipples. The oral cavity is equipped with a small, strong spear expanding knob-like at the base; its size is 10-12, more often 11 micron. The esophagus has the appearance of narrow tube with a small oblong muscular bulbus, behind which the nerve ring is situated. The posterior part of the esophagus is somewhat expanded and has tree esophageal glands, one of which opens at the base of the spear and the other two within the bulbus. The length of the esophagus varies mostly within the limits of 180-220 micron. There is a very clear demarcation line between the esophagus and the intestine. In live worms, the head end of of the body stands out sharply with its translucent contents in the area of the esophagus, extending to where it borders on the intestine. The intestine is characterized by contents of large granules of grayish yellow hue and, therefore stands out well among the other organs. It consists of a long and wide tube-the central intestine and small posterior intestine, ending with the anal outlet on the ventral side near the posterior end of the body; in females, the latter opens out apart from the sexual one, but in males it is combined with the latter and opens into a common cloaca. The sexual organs are upaired and stretch along the body in the form of long, straight tubes beginning near the anterior section of the intestine. Thus, only their anterior sexual tube is well developed. In females, the rudiment of the posterior sexual tube is represented in the form of a posterior uterus performing the role of a semen receptacle [seme-priemnik]. The vulva is pushed far to the back and is at distance equaling 81% of the total length from the head end of the body. Spicules are paired, slightly curved and expanded at the base; before their narrowing down, they form two identical node-like islets set toward the interior. Their length fluctuates between 22 and 32, with an average of 27 microns. The ferrule [Rulek] is represented by a short, simple, slightly curved rod, 11-12 micron in length. Preanal nipples are absent. The eliminating pore is located in the area of the posterior segment of the esophagus behind the nerve ring. (Begin P. 520) Thus, the onion nematode, possessing a series of organizational features common in the stem nematode of potatoes, is distinguished from it by some permanent morphological characteristics: by body length of about 1500 micron by dimension alpha which in females equal 40-50, and in males 45-63, by the position of the vulva which equals 81%, and by the rlatively short bursa which, in most cases, fails to extend to the tip of the tail by 22-23 microns. These distinguishing marks together with the nematode's narrow specialization in a definite subsistence plant - the onion, qualify it as a separate species, Ditylenchus allii (Beijerinck, 1883).

[Page 518, bottom]

Table I. Onion nematode - Ditylenchus allii (Beijerinck) and injuries caused by it. (Illus. by N. N. Kondakov).

1. - Onion nematode. From left to right: the head end, tail of female, posterior end of female body and two eggs: II - initial stages of infestation of seed-onion bulbs by onion nematode. Intensely white spots on first three bulbs indicate places of nematode penetration and concentration in bulbs medium age (midsummer); in last two bulbs nematodes penetrated at point of growth of projecting new rootlets at a later stage of the plants' development. Infested points of growth are abnormally enlarged and have an intensely white color; III - Oblong splitting of garden onion bulb heavily infested by onion nematode; when bulb dried up, worms moved to surface in the form of a cream-colored incrustation (indicated by arrows); IV - small piece of cream-colored crust composed of females, males, and larvae of onion nematode; V - sprouts of seed-onion (seeding of chernushka), (left) two healthy ones and (right) those infested by onion nematode. Infested plants are deformed distended and, in most cases, have no seed capsule at tip.

[Page 519 contains illustrations of onions and of organisms.]

DEVELOPMENT AND MODE OF LIFE

Development. The onion nematode hatches eggs in leaf tissues as well as in the meaty scales of bulbs, obviously, not in the root system. Larvae and adults are, however, likely to be found in root tissues. Upon leaving the egg, larvae differ from mature specimens only by their dimensions and the absence of sexual organs. After a few moltings, they are transformed into adults. Following copulation, the females hatch eggs, and generations follow continually one after another, so that the worm can always be found in the tissues of a host in all stages of its development. Correlation between males and females equal 1:1. Duration of the developmental cycle has not yet been sufficiently investigated, but there is reason to believe that it lasts one month, on the average, and is retarded or accelerated in relation to conditions; the latter have not been sufficiently clarified, but laboratory observations indicate that optimal temperature for the development of onion nematodes lies within the limits of 10-14° C, and egg hatching can occur even at 9-10° C.

If an infested plant dies, the nematodes leave it, enter the soil and search energetically for a new host. A necessary condition for their removal and migration is humidity close to 100%. If humidity is low, they remain in the tissues and dry up together with them. In such a case, their body assumes the form of a spiral wound several times; with the coming of beneficial moisture, the body straightens out. All phases can be subjected to drying without endangering life. The duration of a stay in a bulb in a dried-up state is very extensive. Goodey (1933) succeeded in reviving worms which had spent two years in a dry bulb; in our experiments, all phases survived drying within seed-onion for 15 months and resumed activity in 2-3 hours after being transferred to water. Nonetheless, an attempt to revive nematodes which had spent 4 years and 8 months in a dry bulb ended in failure. Anabiosis in nematodes can occur only if the air surrounding the disintegrating bulb or other parts of the infested plant is well ventilated. If, however, the infested plant is subjected to fermentation and decaying prior to drying, then the nematodes will perish, for they cannot endure the injurious action of decomposed tissue products of the host plant. Such decomposition occurs mostly during storage. If the dying-off of bulbs occurs in relatively dry storage, then the nematodes crawl out in masses, and accumulate on the surface of bulbs forming a pale cream-colored, porous coating or little lumps (table III) composed wholly of worms in different stages of development. The bodies of the worms are wound in spirals and are entwined with each other so tightly that they form close little knots. The removal of nematodes was observed also on the wall of a glass cylinder [Begin P. 521] containing sick bulbs (table III, V), on paper in a herbarium pasteboard box, and on the surface of onion tops of herbarium specimens of seed onions; on the surface the leaves had not been injured, but as the nematodes were leaving the bulb they formed a nodular coating on the leaves. Finally, many nodular formations composed of nematodes were noted on the surface of an entire bulb of a mother-onion [lukamatki] from which the jacket scales [cheskui rubashki] had been removed preliminarily: evidently, nematodes are capable of getting out not only through cracks, but also through undamaged tissues of coverings where they are not very tough. The ability of the onion nematode to remain in a state of anabiosis not only within the dry parts of a plant, but also without them, had remained unnoticed. The removal of nematodes onto the surface of a plant, similar to the one described by us, has been noted solely by S. Rostrup (1926) who had observed the exit of last phase larvae through the crack in a narcissus bulb. In leaving, the larvae also formed a white or cream-colored porous coating; Rostrup transferred these larvae onto an onion and infested it.

The duration of nematode viability in the form of the described coating, composed entirely of worms, is not known; it can be assumed that it lasts at least 15 months, since that time period was the deadline in our experiments. If infested dried up bulbs are shaken up during sorting, or under other circumstances, the nematode coating can easily crumble and spill onto healthy bulbs which are infested by the parasite when favorable moisture conditions set in. In the soil itself, the worm, supply is not big; analyses conducted at various times at depths from 0 to 60 cm have shown that in the summer time only single worm specimens are found in the soil, and only in horizons above 20 cm. Infestation of fields by the onion nematode may be due to planting slighly infested bulbs, and also to the introduction of worms, in a state of anabiosis (in the form of the described coating), which are dropped in the soil accidentally together with healthy bulbs. Another source of infestation is the post-harvest waste (dry scales, tops etc.) has been removed, the percentage of infested plants and bulbs is considerably lower than that on test lots where it has not been removed (table 3). It must be taken into account that infestation may be due to nematodes which inhabit the soil itself, for there they can dispense with food for an extended time. In laboratory experiments, with humidity close to 100% and at a temperature of 9-12° C, nematodes were without food, yet in a state of continuous motility for over 3 months. It can be assumed that in nature this time-period is even longer thanks to the ease with which nematodes drop into a state of anabiosis and revive again. To illustrate this fact, we shall cite the following experiment. On October 23, 1939, about a thousand nematodes which prior to that date had been about a month in an anabiotic state in a bulb, were placed in a drop of pure water on a slide. Two hours later, the worms were already moving around energetically and some of the females were hatching eggs; soon the water evaporated, the worms ceased moving, and stretched out; on October 25, i.e., two days later, a small amount of water was poured on the slide and all worms revived within 1-2 hours, with the larvae reviving before the adults. The experiment was repeated on October 29, November 15 and December 9, and mass movement of larvae and adults took place; in all instances only on November 15 and December 9 a part of them died off; the experiment was conducted in a room where the temperature was 10-12° C and the humidity of 51%. [Begin P. 522, paral]

Distribution of the onion nematode is, undoubtedly, aided also by seed. In the year 1888, Ritzema-Bos established that infestation of dark-onion seed can reach 3%. According to an oral report of N. M. Sveshnikova, infestation of onion seed in Kichanzino in 1938 was a little more than 1%; according to our observations, in the same place in 1939, it was under 0.5%, and in 1940 the nematode was found in but one seed out of 2011. Infestation of the ovaries is somewhat greater; of 727 sterile flowers, the nematode was found in two, T a b l e 3

Influence of post-harvest waste on degree of seed onion infestation by onion nematode in flollowing crop year (Kichanzino, Ar$_z$amas District, 1940)

date of Seeding in 1940	Date of analysis in 1940	State of post-harvest waste	No. of test lot	Total collected		Among them				% of infested	
						Healthy		Diseased			
				plants	bulbs	plants	bulbs	plants	bulbs	plants	bulbs
May 19	Aug. 1	Removed in September, 1939	I	61	109	41	80	20	29	34	26.[illegible]
			II	58	108	21	43	37	65	64.8	60
			Total	119	217	62	123	57	94	47.5	43.[illegible]
May 19	Aug. 1	Not removed	III	66	118	3	5	63	113	95.4	95.[illegible]
			IV	57	105	6	24	51	81	89.4	77.[illegible]
			Total	123	223	9	29	114	194	92.6	87

Remarks, For analysis, the nematodes were alloted 5 linear meters diagonally in each test lot.

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one in each. The membranes of seed pods were infested the most; they were found to contain 15 nematodes out of 1369 analyses (table 4).

The slight infestation of seed in the year 1940 can be explained by the large number of sunny days during the formation and ripening period of seed. The nematode avoids direct sunrays; therefore surface parts are less invaded than bulbs even in cases of heavy infestation. General infestation of seed depends on meteorological conditions and its rate will be highest in years with rainy and cold summers.

Capacity for active motility. It is claimed that the stem nematode has considerable capacity for active motility. Slogteren (1923) established experimentally that the stem nematode of hyacinths can crawl upward through a 90 cm layer of sand and infest hyacinths planted in it. I have conducted repeatedly the following experiment. I placed a heavily infested bulb on the bottom of a glass cylinder and covered the cylinder with a fitted stopper [pritertaia plastinka]. Inside the cylinder soon developed excess moisture from the evaporated liquid of the bulb, and the nematodes reacted to it by gradually crawling out. Soon they moved in masses onto the bottom and the walls of the cylinder. Within a few hours, part of the nematodes were reaching the top quite rapidly. Thus, in a cylinder 40 cm in height and at an air temperature of 10-12° C, the nematodes climbed 17 cm in the first two hours and in a few more hours they had reached the rim; [Begin p. 523] their density on the walls which was at its thickest at the base kept decreasing as they were approaching the top; this was due to the fact that new batches of worms kept crawling out of the bulb. It is interesting that even in overcast autumn days the nematodes crawled exclusively on the side exposed to light, forming on the glass a unique pattern of many thousands of worms (table III, V). On the side of the cylinder not exposed to light, worms were absent. If the cylinder was turned, the nematodes immediately crawled over to the wall exposed to light, and during an experiment, they did this many times over on overcast as well as on sunny days. Nonetheless, nematodes react negatively to the action of direct sunrays and they crawl rapidly to the side of the cylinder not exposed to them.

The nematode is capable of moving fairly rapidly in soil as well; this was confirmed by our observations in one of the greenhouses at Petrodvorets: infested bulbs were placed in empty flower pots that were set under a rack on which experimental young crop of the dark onion was laid out; neither the soil nor the onion seed had been infested. After 2-3 months it was proved that the nematodes had crawled into the rack and infested the onion plants. Thus, they had crawled no less than 50 cm and, incidentally, they did this during two days of heavy, incessant rains, when air moisture in the green house was close to 100%.

Conditions of temperature. The action of temperature on nematode activity has been studied but little. On the basis of some of our observations and experiments and also on information available in literature, it can be assumed that relatively low temperatures are the most favorable for it. Thus, the greatest motile activity of the worms was observed at 9-12° C; these observations are, however, incomplete and approximate. At a temperature of 9-12° C, the nematodes not only climb upward on the cylinder walls, but they dispense with food for quite a long time without losing motility. In contrast, the observations at Kichanzino showed that at 30° the worms moved considerably slower: after liaving the bulb, it took them 2 hours to climb no more than 2-5 cm on the cylinder walls, and they never reached the top, although the height of the cylinder measured but 15 cm. There is also the possibility that, in addition to high temperature, adverse action was exerted on the nematodes by extremely bright summer light. At a 30° temperature, the worms remained visable within the cylinder no more than 2-5 days, perishing as a result of tissue fermentation in the bulb. The fact that moderate temperatures are more favorable for the onion nematode has been confirmed by artificial infestation of bulbs under laboratory conditions. The most typical picture of disease is obtained at 10-12° C. In the field, the process of decomposition of infested bulbs proceeds more typically at 9-14° (manifestation of whiteness and porosity of tissues of internal scales). In instances of high temperatures, the bulbs decompose extremely quickly, but mainly as a result of rapidly-proceeding fermentation within them.

Low temperatures delay decomposition of bulbs, but disease shows gradual progress even at 1-3° C, although it develops at an obviously slower tempo. Nematode motility at 1-3° is slow, but it does not stop completely. Nematodes from three bulbs in the cylinder at a temperature of 1-3°, crawled out and out and concentrated on a wall in nodular which resembeld very much the pale cream-colored coating that forms in onion storage rooms when infested bulbs grow dry. The nematodes remained in this state about a month, but just as soon as the temperature had risen to 7-8°, they separated and crawled all over the wall exposed to light. [Begin P. 525] Thus, the nematode easily survives a drop in temperature to 1°, retaining some, if ever so limited, motile capacity. Normal motility, however, requires temperatures not under 7-8°. Whether or not temperatures below 0° are detrimental and, if so, to what extent, is difficult to say: no experiments were conducted in this direction.

We did, however, have a heavily infested bulb that had been in pit storage [burty] under the snow in Leningrad all winter long; efforts to revive nematodes taken from this bulb ended in failure. From the looks of the bulb it could be concluded that it was frozen and that the nematodes apparently, had perished with it; nearby, healthy bulbs had not been damaged. In contrast to this observation, agronomist M. V. Krylova of the Arzamas base (oral report) asserts that nematodes had survived the very severe winter of 1939-1940 in infested bulbs above ground at the experimental base, as well as underground a depth of 10-50 cm. Unfortunately, in Krylova's experiments the degree of nematode motility after overwintering was not sufficiently verified. Thus, the negative influence of temperatures below 0° on nematode viability remains an open question, but it is clear that their ability to survive a sharp rise or drop in temperature depends to a considerable extent on the moisture in their immediate environment. While in a state of anabiosis, the worms, naturally, are more resistant to sharp fluctuations of temperature than during normal activity. Concomitantly with the above, the surprising adaptability of nematodes to drying propts the hypothesis that they are no les resistant to the action of low temperatures, and that this circumstance may be connected with a definite phase in their cycle.

Trans. A. 526
T a b l e 4.

Results of analysis of onion nematode - Ditylenchus allii Beij. - infestation of onion seed gathered from heavily infested plants of the 1940 yield

Nos. Consec. order	Degree of infestation of different parts of mother-onion plant: Bulb	Shoot strela. Upper part	Shoot strela. Lower part	Total ovaries analyzed	Degree of seed infestation, including: with nematode	without nematode	those with nematode in seed: found	Did not find	those with nematode in sterile flowers: Found	Did not find	Infestation degree of seed pod membrane: Total membranes analyzed	of these: with nematode	without nematode
1	Heavily infested throughout	No nematodes found		116	--	116	--	92	--	24	No analysis		
2	Same: bulb entirely destroyed	Same		92	--	92	--	78	--	14	"	"	"
3	Same.	Single nematodes	Nematodes comparativly few	98	--	98	--	98	--	--	"	"	"
4	Entire bulb heavily infested, with deep crack from root to neck	No nematodes found	Very many nematodes	847	2	845	--	466	2	379	466	10	45[illegible]
5	Same, without crack	Single nematodes	No nematodes	744	1	743	1	516	--	227	517	5	51[illegible]
6	Only half of bulb heavily infested	No nematodes	Many nematodes	841	--	841	--	760	--	81	386	--	38[illegible]
			Total	2738	3	2735	1	2010	2	725	1369	15	1354

The problem of temperature influence on the development and viability of the onion nematode calls for experimental investigation; its solution has a direct bearing on the development of control measures, particularly on the extablishment of an appropriate regime of temperature in onion storage rooms.

INFLUENCE OF ONION NEMATODE ON PLANT ORGANISM.

With reference to the older works clarifying more fully the influence of the onion nematode on the organism of the host-plant, recognition is due the work of Ritzema-Bos (1888) who offers a fairly good description of the disease in very young sprouts of the seed-onion and in older plants of the garden onion. In recent works, this question is accorded the greatest attention in the investigations of Chitwood and Newhall (1940) and in an article by the same authors written in collaboration with Clement (Chitwood, Newhall a. Clement, 1940).

We have succeeded in obtaining more complete data concerning the nematode disease of onions under field conditions as well as under storage condition and, therefore, find it necessary to dwell on them in greater detail. Our observations and experiments were conducted under natural conditions in the years 1939-1940 on young crop at the Arzamas base of the Gorki Regional Experimental Station for Field Husbandry in the village of Kichanzino. In addition to these, experiments were conducted in greenhouses and on the experimental field at the Leningrad Station for Plant Protection in Petrodrorets. Besides these, some of the experiments were carried out in the laboratory for Lower Worms of the Zoological Institute, Academy of Sciences, USSR, at Leningrad. These observations show that the disease manifests itself variously, depending on the developmental phase of the plant and the place where the nematodes penetrate its tissues, and, at the same time, has a series of general characteristics. [Begin P. 526]

Disease of seed-onion. Nematodes can penetrate onion seed (onion-chernushka) at the earliest phase of their germination, as a result of which part of the sprouts do not even appear on the surface, as was demonstrated by Ritzema-Bos (1888) and Laidlow and Price (1910). The very sparse plants that do appear are sharply distinguished by their dwarfish growth and abnormally distended, frequently twisted shoots (table 1, V). In healthy plants, the cotyledons always bear an empty seed capsule at the end; sick cotyledons, however, throw it off considerably earlier, and, therefore, it is often absent in the sprouting first leaves. Shoots of infested plants have at various places irregular swellings, more often at the base, but sometimes also somewhat higher; in the latter case the young plants soon cease growing altogether. The swollen part of the shoot begins to dry at both ends and gradually becomes disconnected from the root, but retains its green color and continues to live. A large amount of worms develops within it hastening the process of its decomposition. In some cases sick plants continue to develop, but fall behind control sprouts and perish within one-two months. Plants infested but slightly live a little longer, but the symptoms of disease are similar: retarded growth, thickening and malformation of shoots, shortening and thickening of internodes (table II, I). Those infested at a later date, for instance, during the formation of bulbs, vary but little from healthly plants at the beginning of the disease; if, however, such a plant were pulled from the ground, then an intensely white spot indicating the locale of nematodes would be found on the bulb. The worms infiltrate a bulb mostly at the bottom, hence this spot is usually near the bottom, bordering on it with one of its edges. However, in view of the softness of bulb tissues in young plants, nematodes can penetrate them anywhere and the white spot can be observed at different places (fig.1). The dimensions of the spot umistakably, indicate the degree of infestation since they are determined by the amount of nematodes that have infiltrated the bulbs or have developed within them. Sometimes infestation occurs via the leaves, through the stomata of which the nematodes make their way to the internal layers and then migrate within the bulb. Damaging the deeper as well as the upper scales of a bulb, the worms populate it evenly, [Begin P. 527] as a result of which the whole bulb assumes an intensely white color. The nematodes destroy chiefly intercellular tissue substances, but they often damage the cells as well; the latter become separated from each other and acquire the form of a porous, brilliantly sugar-white mass, assuming later on a light brown hue. More or less deep cracks form during this period or earlier, particularly if infestation is uneven, and break the jacket scales and the open succulent little scales lengthwise from the bottom to the neck. Very often, cone-shaped closed bulb scales, project themselves out in the forms of a deep cleft and, together with the buds which they protect, they form a likeness of nodes on the bulb surface. Sometimes these protruding scales split in turn longitudinally, acquiring a resemblance to the tuft from small separate scales of leaflets, (table II). Such a picture is usually observed in cases of concurrent infestation of bulbs by nematodes and the onion fly. Though they continue to stand upright, the sick plants are gradually swamped by countless nematodes which eventually destroy their tissues, and in 1-3 months the plants perish. The tissues buried in soil decompose and disintegrate into a powder; the surface parts (leaves) dry up rapidly in the sun and wind. The nematode is found in large numbers in dried up leaves. If infestation occurs at the very end of the vegetative period, then the picture obtained is somewhat different and the course of the disease is typical of that characteristic for the garden onion.

Fig. 1. Sprouts of dark onion injured by onion nematode. Two upper boxes - Kaba variety, lower - Arzamas variety. The two boxes on the left were infested infested artificially with the onion nematode at seeding, the two on the right - uninfested controls. All infested plants perished at an early age: first the less resistant Arzamas variety, and then - Kaba variety. (Illus. by T. A. Gavrilova from photos).

The rate at which nematodes penetrate young onion sprouts is very high, they can accomplished it in a few hours. Thus, by introducing nematodes into the soil containing onion sprouts in experimental containers, a considerably number of worms can be found in the plants after 24 hours.

Infestation by the onion nematode affects the nutritive properties of onions. Upon instruction of farm leaders [kolkhozniki], infested bulbs are used almost exclusively for cattle feed and in the preparation of "lukovniki" (a local dish consisting of finely-minced onions with a small admixture of flour baked in a Russian oven). Infested onions are not fit for other types of food; they impart to cooked food an unpleasant odor.

A comparison of the nutritive properties of plants infested by the onion nematode and of healthy plants used in food in the form of green onions has shown that the sugar and nitrogen content in healthy plants is somewhat higher than that in infested plants. The results of a chemical analysis of the nutritive properties of infested and healthy plants of the seed onion, harvested in 1939 at the experimental base in the village of Kichanzino, are cited below. Figures represent percentage of substance content:

	Invert sugar	Sacharose	Nitrogen	Cellulose	Saccharosity	Moisture
Onion infested by nematode....	1.78	7.42	0.49	0.89	9.3	84.4
Onion not infested.........	1.27	10.39	0.52	0.73	11.66	82.41

These analyses were conducted by the Agrochemical Laboratory of the Gorki Regional Experimental Station for Field Husbandry. [Begin P. 528]

Disease of garden onion. Nematodes have two ways of penetrating plants of the garden onion as well as those of the seed onion: through the bulb and through the leaves. Depending on meteorological conditions, one way of nematode penetration may hace its advantages over the other. In times of short but heavy rains followed by bright sunny weather, nematodes generally penetrate the bulb near the bottom at the points of growth of sprouting rootlets. In this case, the first symptom of infestation is a marked swelling of the points of growth which enlarge to such an extent that they are 2-3 times the size of the neighboring healthy ones, and assume an intensely white color. The disease spreads gradually to the nearby points of growth of rootlet embryos, which in turn become enlarged and acquire a brilliantly white coloring. Between these and the bottom end there soon appears a small crescent-shaped cleft which increases in size as the disease spreads and is likely to take on a circular shape. The jacket scales on the infested area glide upward and are easily blown away when the bulb is pulled from the ground. The upper, succulent scales (1,2,3 and above, depending on phase of disease) also glide below the circular or crescent-shaped cleft, moving over farther form the ruptured area and exposing the internal succulent scales (table II, II). The longitudinal splitting of bulbs form the bottom to the nick, including jacket scales and meaty scales as well, is widespread and easily detected when crops are inspected. Longitudinal cracks often continue at the bottom and split that, also (table II, II and III); in such a case, the circular cleft may be absent. A break in the upper scales facilitates the projection of a considerable part of the lower scales.

During long, drizzly and often cold rains, nematodes crawl from the soil onto the surface, climb energetically onto the plant, and penetrate the leaves through the stomata. In such cases, the initial phase of the disease proceeds more latently, because the worms have attacked the internal tissues of leaves and bulb scales. The disease can be discovered only at a later date, when the bulbs are heavily infested.

Leaves of infested plants become very brittle and tough; they crack and crumble from a touch; their coloring loses its evenness due to deformation of lamina, and segments of white tissue. With experience it is fairly easy to detect infested plants by their external look. Invasion of plant parts by nematodes is irregular. A favorite place for the concentration of worms is the bulb, next the leaves and stem shoot. They roots but slightly and seed even less. For the purpose of illustrating the degree of worm infestation of the leaves and root system of the garden onion, whose bulbs were very heavily infested by nematodes, the results of analyses conducted at Kichanzino in 1940 are cited on table 5.

Table II. Injuries caused by onion nematode - Ditylenchus allii (Beijerinck). (Illus. by N. N. Kondakov)

I - From left, healthy plants, and from right, infested plants of seed onion (young crop of chernushka) at an early age; II - infested bulbs of garden onion: left - initial phase of infestation; enlarged, intensely white points of growth of rootlet embryos and of adjacent bulb tissues; are visible; at center - formation of cleft between bottom and bulb scales, with their subsequent gradual splitting longitudinally and sliding upward; from right - same, at later phase of disease; III - cracking of bottom of garden onion bulb heavily infested by onion nematode; IV - external appearance of seed onion plants infested concurrently by onion nematode and onion fly. As a result of longitudinal splitting of bulbs, part of covered cone-shaped, scales have projected themselves outwards in the form of leaves; V - form of tip of tail in pea population of onion nematode.

Table II

[Page 529 contains illustrations described above.]

Table 5.

Degree of worm-infestation of different parts of garden onion as per observations at Kichanzino in 1940.

Date of analysis	Total plants analyzed	Those infested by nematodes					
		Bulbs		Leaves		Roots	
		Number	%	Number	%	Number	%
Aug. 31	56	56	100	Analysis not available		13	23.2
Aug. 5	52	52	100	37	71.1	17	32.6

Table 5 shows that even in extremely heavily infested plants, the percentage of worm-infestation of rootlets is several times less than that in bulbs and leaves. Furthermore, the number of worms in the rott system usually does not exceed 10-20 specimens, yet inside of bulbs and leaves they number many tens of thousands.

Disease in bulbs under storage conditions. Bulbs slightly infested by nematodes usually acquire a completely healthy look after they have been dried in the sun, and they can easily be mistaken for healthy ones and stored together with those actually healthy. Infestation, however, becomes evident in 1-3 months, depending on the number of nematodes within the plants at the time they were stored and on humidity and temperature in the storage room. Jacket scales darken gradually where nematode concentration is the greatest, and they form a line of demarcation between themselves and healthy tissue segments; because of this, the scales on sick areas appear to be wet and have an irregular cacao coloring; sometimes yellow-white or muddy-gray spots of irregular contours and different sizes appear on these areas. The bulbs grow ever softer as they decompose, yet their jacket scales become brittle and are easily blown away. On a transverse crack of a bulb, the internal meaty scales in sick areas are composed of very brittle, white, or cream-colored disintegrating tissues (table III, IV) which under the microscope are found to consist of a great number of worms and an admixture of plant cells.

When the disease has spread over a large part of the bulb, small clefts serving the nematodes as an exit. In some cases appear on its outer surface.

Table III. Concentration of the onion nematode - Ditylenchus allii (Beijerinck) in plants and on various objects. (Illus. by N. N. Kondakov)

I. II, III - formation of a cream-colored coating consisting of nematodes in herbarium specimens of onion plants; I - accumulation of nematodes on the surface of leaves and near the bottom of the bulb, 2 - on surface of transverse cut of bulb, 3 - on herbarium paper; IV - transverse cut of a garden onion bulb heavily infested by the onion nematode; darkened sections of scales with jagged, uneven margins - areas most heavily infested by worms; V - worms in motion on wall of glass cylinder exposed to light, forming on glass a unique pattern; at bottom of cylinder - bulb heavily infested by stem nematodes which they have abandoned; VI - longitudinal cut through part of stem, root neck and root of a tomato infested by onion nematode; maximum concentration of worms is observed in pith which acquires a brown coloring and becomes badly disintegrated; VII - bulb of garden onion heavily infested by onion nematode under storage conditions. In areas of worst infestation, jacket scales have an irregular coloring and appear to be wet.

Table III.

[Page 531 contains illustrations described above.]

A deep longitudinal split of the entire bulb [Begin P. 532] is observed. It reveals the internal meaty scales, part of which are likely to be covered with a nematode coating, as the worms move to the surface. Conditions favoring nematode removal to the surface have not yet been sufficiently investigated; therefore, it is hard to explain why in some cases it has a mass character and forms a fairly thick coating consisting of nematodes; yet, in others it is not observed at all. Observations not sufficiently verified create the impression that the intensive removal of nematodes is due to temperature and, possibly, to moisture. Apparently, a very important role is performed also by a good preliminary drying of the bulbs in the sun before they are put in storage. In the latter case, as observed on a small amount of material, the nematodes hardly ever come out on the surface of the bulbs, especially when clefts are absent.

If decomposition of bulbs occurs when moisture is low, then they dry up and in the end there is nothing left of them but the covering. Outwardly this destruction may remain unnoticed and may be discovered only by touch. The length of time required for the complete destruction of bulbs equals, on the average, the developmen al cycle of 2-3 nematode generations. At a 10-12° C temperature and air humidity of 50-60% it takes about 2-3 months. It humidity is high and tiemperature above 15° C, invasion may be complicated by a rapidly developing fermantation in bulbs, the action of which is as destructive to nematodes as it is to bulbs. In such cases decompoistion of bulbs proceeds even more rapidly, often forming a wet rot accompanied by a very unpleasant odor.

Destruction of bulbs infested by nematodes can be hastened also by a secondary infection caused by representatives of fungus or bacterial flora; the activity of the latter causes mass killing and destruction of worms, and the end result presents so atypical a picture of bulb destruction that sometimes its initial cause is difficult to determine. Decomposition of bulbs infested by nematodes is accelerated also by the presence of plant parasitic mites which greatly change the picture of the disease. The mite Rhizoglyphus echinopus Fumouze et Robin[1] not only injures the bulb, but eats the nematodes in its tissues. In the year 1940, the author [of present article] observed repeatedly how this mite destroyed almost completely a coating on the surface of a bulb that consisted of many thousands of nematode specimens. One could see under the microscope scraps of worm bodies with mites of different ages moving among them and among their eggs.

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[1] Mites identified by V. V. Rodikortsev.

FOOD SPECIALIZATION

The onion nematode belongs to the list of organisms closely adapted to feeding on certain plant species. As Goodey (1933) pointed out, it can transfer from the onion to a series of other species of the genus Allium. Thus, it injures garlic - A. sativum L., leek - A. porrum L., chives - A. schoenoprasum L., Shallot onion - A. ascalonicum L. and the wild onion - A. vineale L.

As per our observations, it injures in the USSR the following varieties of the garden onion (A. cepa L.): the Arzamas, Bessonov, Kaba, Tsitaus, Pogar, Strigunov and the Mstersk. [Begin p. 533] According to our experiments, it injures also tomato and pea plants.

Susceptible tomato varieties (Solanum lycopersicum L.). To investiga- the possibilities of the onion nematode's transfer from onions to tomatoes, we tested three varieties: Chudo-rynka, P'eretta and Sparks-Erliana. The first two were grown in a greenhouse and on the test lot at Petrodvorets, on the experimental farm of the Leningrad Regional Experimental Station for Plant Protection. Plants were infested artificially with nematodes while still very young. Sparks-Erliana and in part Chudo-rynka were tested in experiments conducted on young crop at the Arzamas base of the Gorki Regional Experimental Station for Field Husbandry under conditions of soil naturally and heavily infested by the onion nema... The experimental results are cited on table 5. The highest rate of infestation was observed in Sparks-Erliana (38.6%) and in P'eretta (12.6-3%); the least infested was Chudo-Rynka.

We are not inclined to consider this inequity in infestation as an indicator of varying resistance in the varieties tested, because the conditions of natural infestation at Kichanzino can hardly be compared with the artificial conditions at Petrodvorets. Furthermore, observations of the P'eretta variety have shown that plants of the same variety may be susceptible to nematode infestation in different degrees, depending on the age of the sprouts. The P'eretta variety became infested in different phases of development: part of the plants were infested at the formative stage of 3-4 leaves, the other part - at the stage of 12-14 leaves. Older sprouts were infested soon after the seedlings were transferred from a box to a greenhouse rack; younger sprouts were grown directly on the rack and were not transplanted before nematode introduction. Infestation was accomplished on May 31, 1939. Two weeks later, on June 16, part of the plants was transplanted in the open, and part was left on the same racks. Infestation was not repeated in open ground. At the end of the vegetative period, it was established that tomatoes of the P'eretta variety inoculated in the phase of 12-14 leaflets were more worm-infested than those inoculated in the phase of 3-4 leaflets. Of the first group of plants grown in the greenhouse, 19 were analyzed and 11 of those were found to be infested, and in open ground, 8 plants out of 22 were infested. At the same time, of 92 plants grown in the greenhouse and inoculated in the phase of 3-4 leaflets, nematodes were found in only 3. It is possible that the weakened condition of the plants caused by transplantation was more condusive to infestation.

In infested plants, the nematodes were usually found in the axial part of the center root, in the neck of the root, and in the part of the stem adjacent to it (fig. 4, VI). In infested segments, the worms were represented by a colossal number of eggs, larvae, and adult specimens. The tissues were porous, had acquired a brown color, and were destroyed in some places. Outwardly the infested plants differed but little from healthy ones, only in some cases, longitudinal cracks of the main stem in the area where side shoots branch out were noted on Sparks-Erliana. Infested plants appeared more brittle and broke easily. In the upper part of the stem, nematodes usually were absent and petioles of leaves were not infested; gall formations on stems were not found. It must be noted that, according to the work of Williams (1936), the only source of information on tomato injury caused by the stem nematode, the parasite is responsible for a peculiar, spongy gall formation on plant stem and petioles at base of lamina. Perhaps [Begin P. 534] this case should be treated as parasitism of some other species of the stem nematode, distinct from the onion nematode by virtue of the character of its injuries.

The pea (Pisum sativum L.) as a subsistance plant of the onion nematode.

In the course of the work at Kichanzino, in 1939, our attention was called to the relatively heavy infestation of peas by the onion nematode (Uladovskii M III variety). Of 16 plants analyzed, nematodes were found in large numbers in 11 plants. The plants on test lots looked bad because they had rust and dark spots on the leaves indicating infection caused by the nematode and fungus diseases concomitantly. A similar condition was noted on the 1940 crop, when the nematode was found in 34 plants out of 73 analyzed (46.5%). In these cases worms were found in very large numbers.

Transfer of onion nematode to other subsistance plants. To explain the contingent of subsistence plants of the onion nematode, [Begin P. 536] analyses were made of more than 4 thousand plants (besides the garden onion) which belonged to over 40 varieties and species (tables 7 and 8). In relation to the nematode, these plants can be broken down in three groups. The first group includes onions, tomatoes and, probably, peas in the tissues of which the nematode can multiply. In the second group should be included crops which attract the nematode, but in the tissues of which it cannot propagate. The third and final group includes plants on which the nematode cannot multiply and which, in general, do not attract worms.

Table 6.

onion nematode infestation
Results of analysis of different tomato varieties at Kichanzino and at Petrodvorets in 1939-1940

Name of variety	Place of analysis	Year	Total plants analyzed	Number of plants analyzed: In greenhouses: Had nematode	In greenhouses: Did not have nematode	In greenhouses: % of infested plants	In open ground: Had nematode	In open ground: Did not have nematode	In open ground: % of infested plants
Sparks-Erliana	Kichanzino	1940	145	--	--	---	56	89	38.6
Chudo-Rynka...	"	1939	4	--	--	--	1	33	25
P'eretta: a) infested plants...	Petrodvorets	1939	29	--	--	--	10	19	34
b) controls...	"	1939	21	--	--	--	--	21	--
P'eretta: a) infested plants...	"	1939	111	14	97	12.6	--	--	--
b) controls...	"	1939	94	--	94	--	--	--	--
Chudo-Rynka: a) infested plants...	"	1939	35	2	33	5.6	--	--	--
b) controls...	"	1939	50	--	50	--	--	--	--
Chudo-Rynka: a) infested plants...	"	1939	61	--	--	--	3	56	5.2
b) controls...	"	1939	43	--	--	--	1 [1]	42	--
Total	--	--	893	--	--	--	--	--	--

[1] Nematode found in one control plant growing near the demarcation line of those infested.

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Table 7.

Results of analysis of to onion nematode infestation of cultivated plants and weed grown on naturally heavily infested soil in the village of Kichanzino, District.

Nos. consec. order	Name of plants	Total plants analyzed	with nematode (Plants)	without nematode (Plants)
	Cereals (Gramineae)			
1	Oats, Zolotoi Dozhd' variety (Avena sativa L)	126	--	126
2	Rye (uncertified seed) (Secale cereale L.)	15	--	15
3	Winter wheat uncertified seed) (Triticum vulgare Host.)........................	9	--	9[1]
4	Spring wheat (uncertified seed) (Triticum vulgare Host.)........................	119	--	119[1]
5	Millet (uncertified seed) (Panicum miliaceum L.)........................	186	--	186[1]
6	Barnyard millet (Panicum crusgalli L.)...	6	1	5
	Mustard family (Cruciferea)			
7	Cabbage, Ranniaia No. 1 variety (Brassica oleracea var. capitata)................	105	1[2]	104
8	Turnip, Ostorzundomskii variety (Brassica rapa L.)...............................	132	16	116
9	Turnip (uncertified seed) (Brassica rapa L.)	43	19	24
10	Radish, Pink with white tip variety (Raphanus sativus var. radicola Pers.)...	110	1	109
11	Mustard (uncertified seed) (Sinapus juncea L)	26	7	19
12	Horse radish (Nasturtium semoracia Fr.)....	2	--	2
13	Shepherd's purse (Capsella bursa pastoris Mnch.)	6	--	6
	Potato family (Solanaceae)			
14	Tomato, Sparks-Erliana variety (Solanum lycopersicum L.)........................	145	56	89
15	Tomato, Chudo-Rynka variety (Solanum lycopersicum L)	4	1	3
16	Makhorca (Nicotiana tabacum L.).............	102	--	102
17	Potato, Epicure variety (Solanum tuberosum L.)	114	3	111
18	Potato, Scianets 423 and 3398 variety (Solanum tuberosum L.)........................	5	1	4
19	Eggplant (uncertified seed) (Solanum melongena L.)	121	3	118

Table 7 Continue

Nos. consec. order	Name of plants	Total plants analyzed	with nematode	without nematode
			Plants	
	Leguminous plants (Leguminosae)			
20	Alfalfa, Grimm Zaikovich variety (Medicago media Pers.)................................	84	5[2]	79
21	White clover (Trifolium sp.)..............	71	--	71[3]

1 Grain crops were found to have a paritcular variety of the onion nematode characterized by small dimensions (less than 1 mm).

2 On cabbage, alfalfa and carrots, worms were found chiefly in early July, immediately after heavy rains which had a stimulating effect on them and encouraged their coming to surface of soil.

3 Stem nematode species particularly adapted to white clover and cucumbers were found on these crops; the nematode found on cucumbers was distinguished by a sharply pointed tail and small dimensions.

[Table 7.] (Continued [from page 536])

Nos. consec. order	Name of plants	Total plants analyzed	Plants with nematode	Plants without nematode
22	Red clover (Trifolium sp.)......................	16	7	9
23	Peas (Pisum sativum L.).......................	89	45	44
24	Vetch (uncertified seed) (Vicia sativa L.).....	20	4	16
25	Lentil, Petrovskaia 4/105 variety (lens esculenta Mnch.)..................................	13	3	10
	Goosefoot Family (Chenopodiaceae)			
26	Beet, Egyptian variety (Betavulgaris L.)........	74	6*	68
27	Fodder beet (Beta vulgaris L.)..................	13	11	2
28	Mountain spinach (Chenopodium sp.).............	11	--	11
29	Amaranth (Amaranthus sp.)......................	2	--	2
	Carrot family (Umbelliferae)			
30	Carrot, Nantskaia variety (Daucus carota L.)....	71	15[2]*	56
31	Parsley, Sakharnaia variety......................	102	1	101
32	Dill (Anethum graveolens L.)....................	16	--	16
	Thistle family (Compositae).			
33	Lettuce (Lactuca sativa L.)....................	29	5	24
	Gourd family (Cucurbitaceae)			
34	Cucumber, Myromskii variety (Cucumis sativus L.)	115	--	115[3]
35	Cucumber, Viaznikovskii variety (Cucumis sativus L..	100	--	100
	Waterleaf family (Hydrophylaceae)			
36	Tansy (Phacelia tanacetifolia Benth.)...........	299	39	260
	Flax family (Linaceae)			
37	Flax (Linum sativum L.).........................	76	2	74
	Mint family (Labiatae)			
38	Unidentified weed...............................	1	--	1
	Total...........	2578	252	2326

*For footnotes see preceding page.

Table 8

Results of analysis of onion nematode infestation of cultivated plants inoculated artificially at an early age and the grown in a greenhouse and in open ground at Petrodvorets

Nos. in consec. order	Name of plants	Total plants analyzed	Plants with nematode	Plants without nematode
	Cereals (Gramineae)			
1	Oats, Zolotoi dozhd' variety (Avena Sativa L.)			
	a) infested plants	62	--	62
	b) controls	50	--	50[1]
2	Winter wheat (uncertified seed) (Triticum vulgare Host.):			
	a) infested plants	21	--	21[1]
	b) controls	5	--	5
	Mustard family (Cruciferae)			
3	Cabbage, Ranniaia No. 1 variety (Brassica oleracea var. capitata L.):			
	a) infested plants	43	--	43
	b) controls	72	--	72
4	Radish, Rynochnyi Krasnyi variety (Raphanus sativus var. radicola Pers.):			
	a) infested plants	159	145	14
	b) controls	108	--	108
5	Radish, Ledianaia sosulka variety (Raphanus sativus var. radicola Pers.):			
	a) infested plants	104	86	18
	b) controls	30	--	30
	Potato family (Solanaceae)			
6	Tomato, Chudo-rynka variety (Solanum lycopersicum L.):			
	a) infested plants	118	5	113
	b) controls	72	1	71
7	Tomato, P'erotta variety (Solanum lycopersicum L.):			
	a) infested plants	148	25	123
	b) controls	125	--	125

[1] Some sort of particular stem nematode species the dimensions of which were not above 1mm.was found on grain crops.

[Table 8. Continued]

Nos. in consec order	Name of plants	Total plants analyzed	Plants with nematode	Plants without nematode
8	Potato, Ranniaia Roza variety (Solanum tuberosum L.)			
	a) infested plants.	1	--	1
	Leguminous plants (Leguminosae)			
9	Alfalfa (uncertified seed) (Medicago sp.):			
	a) infested plants	1	--	1
10	Clover (uncertified seed) (Trifolium sp.):			
	a) infested plants	28	--	28
	b) controls	29	--	29
	[Begin P. 538]			
	Goosefoot family (Chenopodiaceae)			
11	Spinach (uncertified seed):			
	a) infested plants	2	--	2
	b) controls	2	--	2
12	Beet, Egyptian variety:			
	a) infested plants	97	3	94
	b) controls	45	--	45
13	Beet, Bordo variety:			
	a) infested plants	82	1	81
	b) controls	67	--	67
	Carrot family (Umbelliferae)			
14	Dill (Anethum graveolens L.):			
	a) infested plants	49	8	41
	b) controls	50	--	50
	Thistle family (Compositae)			
15	Daisy:			
	a) infested plants			
	b) controls			
	Gourd family (Cucurbitaceae)			
16	Cucumber, Muromskii variety (Cucumis sativus L.)			
	a) infested plants	30	--	30
	b) controls	8	--	8

[Table 8, continued from page 29]

Nos. in consec. order	Name of plants	Total plants analyzed	with nematode	without nematode
			Plants	
17	Cucmber, Klinskii variety (Cucumis sativus L.):			
	a) infested plants........................	41	4	37
	b) controls................................	23	--	23
18	Cucumber (uncertified seed) (Cucumis sativus L.)			
	a) infested plants........................	28	1	27
	b) controls................................	13	--	13
	Total.............	1744	286	1458

[Bottom p. 536] To the list of plants which attract pests should be added the radish, the fodder turnip [Brassica campestris rapifera], the [repa - Brassica rapa], mustard, tansy, and in part vetch and lentil. Their attraction for the nematode is hard to explain, but there is no doubt that the nematode is glad to invade them and is likely to contentrate there by the tens. In 1939, under field conditions at Kichanzino, the nematode was found in all 16 fodder turnip plants analyzed, in 19 out of 43 turnip plants analyzed, in 7 out of 26 mustard plants and in 9 out of 22 tansy plants. In lentil it was found in all three plants concerned, and in vetch, in 4 out of 10. In most cases the worms were numerous. All plants of this group looked entirely healthy, and an external inspection of the roots revealed no traces of injury. In 1940, the crops referred to showed a considerably smaller percentage of worm infestation. In tansy, nematodes were found in 30 plants out of 277 plants, in the radish, in 1 plant out of a 102, and in vetch, lentil and fodder turnip (10, 10, and 100 plants respectively), they were not found at all. Nonetheless, under conditions of artificially heavily infested radishes, in a greenhouse at Petrodvorets, worms were found in 145 out of 159 radish specimens of the Rynochnyi krasñyi variety, and in 86 out of 104 of the Ledianaia sosulka variety (Table 7). [Begin p. 539] In this particular case the worms remained in the plants until the very harvest. Their absence in the same crop in Kichanzino can be explained only by the late date of analysis, which was performed in the phase of seed maturing, when plant tissues had already lost their freshness and succulence and probably therefore no longer had any attraction for nematodes. Furthermore, in the field, the worms had selective possibilities as to subsistence plants, thanks to the presence of weeds; in the greenhouse, however, there were no other plants besides the radish. The fact that certain phases in the development of the radish have got an attraction for the nematode is so much the more certain, because the worms were found very rarely, or not at all, on other experimental plants, regardless of equal artificial infestation of the soil.

The third group of plants which do not attract the nematode and are not injured by it, includes but a small number of crops: wheat, rye, oats, millet, cabbage, horse radish, makhorca, potatoes, eggplant, alfalfa, clover, beets, carrots, parsley, dill, cucumbers, flax and spinach, and the weeds goosefoot, amaranth, and wild daisy. The possibility that worms stay temporarily in plants belonging to this group is indicated by the following observation. In Kichanzino, in 1939, the nematode was found in many plants of alfalfa, makhorca, carrots and flax immediately after the heavy rains of July 8 and 9th. Under the influence of moisture, the worms crawled all over the lot and, in passing, climbed also on crops to which they are not adapted and which they later left; thus, on the day following the rains, the nematode was found in all 5 alfalfa plants analyzed; yet a month and a half later it was not found in a single plant of 18 analyzed; nor was it found on a single plant out of 61 alfalfa plants in 1940. The nematode was found in one makhorca plant on the day following the rains in 1939, and in none out of 3 a month and a half later; in 1940, it was found in none out of 102 makhorca plants. Of 12 plants of flax analyzed after the rains, the nematode was found in one, and at the end of the vegetative season, it was found in one out of 64. A similar picture was observed on carrots where the percentage of plants inhabited by worms in 1939 dropped considerably toward fall.

compared the July, and in the year 1940 it equalled zero. Consequwnrly, in separate cases, the nematode can be found on crops which do not belong to the list of its subsistence crops. Hence, it cannot be inferred that a plant belongs to the list of nematode hosts, just because the nematode had been present in individual cases.

The nematode was not found on wheat, rye, oats or millet (tables 6 and 7). Nonetheless, a special variety of the stem nematode was found in 4 rye plants, 13 millet, in 2 plants of spring wheat and in 1 of winter wheat in 1939 at Kichanzino; it was found also in 3 plants of oats out of 62 of the infested series, and in 1 out of 50 controls. In addition, this variety was found in 3 plants of winter wheat out of 21 taken form the infested series (Table 7). In the case of weeds, the nematode was found only in one plant - barnyard millet, at Kichanzino in 1939. This happened to be a larva 1017 microns in length and 20 microns in width. Most of the Cruciferae plants investigated as to the nematode are included in the second group by virtue of their attraction for worms (fodder turnip, turnip, radish, mustard). Yet, some of the experimental plants - cabbage and horse radish - obviously must be added to the list of those which do not attract the pest and are not attacked by it. The nematode was not found in horse radish, and of 148 cabbage plants, it was present in only one and was limited to one specimen. It must also be noted that, regardless of heavy artificial soil infestation at Petrodvorets, [Begin p. 540] the 43 cabbage plants grown there were free from pests.

Those of the potato family investigated were: the tomato, makhorca, potato and eggplant. Of these only the Chudo-Rynka and P'erotta tomato varieties proved subject to infestation (see above). Potatoes, makhorca and eggplants may, on rare occasions, be nematode carriers; they are not, however, injured by them. Thus, at Petrodvorets, a potato plant was grown artificially in soil extremely heavily infested; it produced more than ten large, healthy tubers, and not one of them, nor the plant itself, was infested.

The following experiment was conducted on artificially infested potato and beet tubers and onion bulbs. Groups of 20 tubers and bulbs were infected by nematodes by means of introduction of small particles of an infested bulb through a deep cut; the incision edges were brought together with bandages and then the tubers and bulbs were wrapped separately in paper. Half of the bulbs were kept in a cellar at 10-12° C, and half were placed under a shelf in a greenhouse where the temperature fluctuated from 30 to 20 and lower. In 2 months time all bulbs were infested, and most of all those kept at low temperature. No nematodes were found in beets: obviously they all perished. They were absent also in the parts of potato tubers not damaged by incision. A certain amount of larvae were found in but 3 tubers in the place of incision where they apparently had survived ever since they had been introduced in the tubers.

Field observation at Kichanzino showed that even the Epicure variety, one of the most susceptible to the stem nematode, was but mildly infested. Thus, in the year 1940, we analyzed 114 plants of this potato variety and only 3 of them proved to be vectors of a small number of nematodes. All plants looked perfectly healthy, and their yield of more than 1000 tubers was of a high quality; no nematodes were found in them. In eggplants, too, the nematode was found in very limited numbers and only in 3 plants out of 110 analyzed. On the basis of the above and also as a result of the very good condition of the crop in all repeated tests, it can be assumed that eggplants are not subject to injury by the onion nematode. Naturally, the possibility that the nematode may adapt itself to a life on potatoes, eggplants, and other plants is not excluded, especially if a nematode generation grown on tomatoes and other related crops were to be transferred to these plants either in natural environment or artificially.

Plants of the legume family investigated were the Grimm-Zaikevich variety of alfalfa, white and red clover, peas, vetch and lentil. Peas, above, are host plants of the onion nematode, vetch and lentil possess the capacity to attract it. As far as clover and alfalfa are concerned, they are neither injured by the pest, nor do they attract it. Of the 84 alfalfa plants analyzed, the nematode was found in 5 and in all cases on the day following the heavy rains of July 9, 1939. Further analyses, conducted at the end of 1939 and during 1940, have disclosed their complete absence in alfalfa. None of the 71 plants of white clover analyzed had the onion nematode. Red clover proved to be a nematode vector in 7 cases out of 16, with 5 cases being registered the day after the heavy July rains in 1939. The same year, we conducted an experiment in artificial infestation of red clover under laboratory conditions at Leningrad. Seed were planted in sterilized soil [Begin p. 541] in which, a few days later, a large amount of worms was introduced together with fragments of meaty scales from strongly infested bulbs. Sprouts had a normal appearance, and a microscopic analysis of approximately 40 plants revealed the presence of single nematodes in only two plants. A second experiment in artificial infestation of red clover was conducted at Petrodvorets where a considerably large amount of seed had been sown. The experiment was conducted twice, and nematodes were introduced in the soil the same as in other cases, under the roots of young sprouts, with segments of meaty scales from heavily infested bulbs. The plants were developing normally, and an analysis of 28 specimens disclosed a complete absence of nematodes. Laboratory experiments, substantiated by field observation at Kichanzino, justify fully the statement that the onion nematode does not injure clover, and that the latter is not a subsistence plant of the nematode. At the same time, it must be noted that we discovered a special variety of the stem nematode less than 1 mm in length in 1 alfalfa and in 3 clover plants at Kichanzino in the year 1940.

No subsistence plants of the nematode were found among the goosefoot family (tables 7 and 8). In beets, the nematode was found in several instances. In Kichanzino, in the year 1939, the onion nematode was discovered in 6 beet plants of the Egipetskaia variety out of 74 plants analyzed, and 11 plants of the fodder beet out of 13 plants inspected. The greatest incidence (12 out of 17) occurred immediately after the July rains, indicating that the worms had crawled on these plants accidentally. In 1940, no nematodes were found in a single beet plant out of 57 plants analyzed. The beet crop produced a very good yield, and a microscopic inspection of several hundred roots under field and storage conditions failed to disclose any traces of infestation. The nonsusceptibility of beets is confirmed also by experiments conducted in Petrodvorets on the Egipetskii [or Egipetskaia] and Bordo [or Bordeaux] varieties. One of these experiments - a futile attempt at root infestation - has already been described; two others were conducted in a greenhouse. In one of them, nematodes were introduced artificially in unsterilized soil on a rack where beets were being grown; a part of infested and of control sprouts was later transferred to open ground where it was growing until harvest time. The second experiment consisted of growing beets in sterilized soil in boxes at a depth of 20 cm. All together, more than a 100 plants were grown in boxes, and they grew well and produced an excellent yield regardless of whether or not they had been infested by the nematode. During harvest, 407 beet plants of the Egipetskaiā variety and 374 of the Bordo variety were taken for analysis and storage. A large part of the plants grown in sterilized soil in boxes was subjected to micro-analysis. In none on the 41 Egipetskaia variety beet specimens or in the 57 of the Bordo variety, not counting controls, were found nematodes. Of those infested and grown in a greenhouse and in open ground, 56 beet specimens of the Egipetskaia variety and 25 of the Bordo variety were taken for analysis: in the Egipetskaia variety, very few nematodes were found in 3 plants and in the Bordo variety in 1 plant. The relatively small dimensions of the worms (length of females not above 855 microns), together with the fact that in 3 instances they were found in the open ground and in one instance in a greenhouse in plants grown in unsterilized soil, justify the assumption that here, possibly, was involved a stem nematode species other than the onion nematode. The results of storing 490 beet roots (Egipetskaia 265 and Bordo 225) are convincing enough that the onion nematode does not injure this plant. The roots were stored all winter in boxes in a Petrodvorets basement and were inspected in June of 1940. [Beging p. 542] From the group of infested plants 30 roots were analyzed of each of the two beet varieties; the nematode was absent in all specimens.

Plants of the carrot family [Umbelliferae] investigated were dill, parsley and carrots. Dill was seeded in a Petrodvorets greenhouse and infested with the nematode artificially. Growth of the plants was normal and no symptoms of disease were observed. Of the 49 plants used for analysis, the nematode was found in limited numbers in only 8. In Kichanzino, dill was growing all over the experimental lot as a result of self-seeding; of the 16 plants concerned, the onion nematode was found in none. In all probability, dill need not be included at all in the list of host plants of this nematode. The Sakharnaia variety of parsley was transplanted onto the experimental lot at Kichanzino in the year 1940; 102 plants were used for analysis and in one of them was female nematode; no symptoms of disease were noted. Apparently, parsley likewise cannot be considered as a subsistence plant of this pest. The Nantskaia carrot variety was grown in 1939 and in 1940 on the experimental lot at Kichanzino. The plants were analyzed while very young; in 1940, the nematode was found in none of the 26 plants concerned, but in 1939 worms were discovered in 15 plants out of 45. Of these 15, the nematode was found in 12 plants out of 14 analyzed the day after the July rains, and only in 3 plants out of 31 analyzed in the fall. Thus, carrots are not injured by the nematode, but its accidental invasion of this plant can occur.

Those of the thistle family [Compositae] investigated were lettuce and the wild daisy. Lettuce was grown only in 1939 at Kichanzino. During an analysis of 29 plants, nematodes were found in very limited numbers in 5 plants. Wild daisy grown in artificially heavily infested soil in a greenhouse (table 6) proved to be free of nematodes.

Cucumbers were the only species of the gourd family investigated as to possible infestation. Two cucumber varieties - Muromskie and Viaznikovskii were grown in Kichanzino. Both proved resistant. In the Muronskie variety, a distinct species of the stem nematode was found in 2 plants out of 103 analyzed. Its dimensions were not over 1mm and, besides, it was plainly distinguished from the onion type by a very pointed tail. Three cucumber varieties were grown at Petrodvorets - Muromskie, Klinskie, and an unknown variety from White Russia. The nematode was discovered in 4 plants of the Klinskie variety and in 1 of the unknown variety (table 7). We grew sprouts by the tens under laboratory conditions and infested them with the nematode at seeding time. The worms were introduced in the soil by sprinkling it evenly with water containing nematodes in all phases of development, extracted from heavily infested bulbs. Three weeks later, the first batch of sprouts was taken for analysis. The last analysis were made a month and a half later, and of 26 plants analyzed, 2 worms of very small dimensions were found in but one plant; it is possible that these belong to a special variety of stem nematode, distinct from the onion type; seeding had been carried out in unsterilized soil. Analysis of soil surrounding the roots of experimental plants revealed an almost complete absence of the onion nematode, and the 88 specimens found there represented 12 nematode species, but included only one badly damaged female of the onion nematode.

The above account leaves no doubt that the onion nematode is a restricted specific pest that belongs to a particular species of the stem nematode (Ditylenchus allii Beijer.) [Begin p. 543] and is adapted to prasitism on the onion and probably other plants of the genus Allium; from time to time it attacks tomatoes and peas. It is not injurious to a series of the more important agricultural crops, such as beets, potatoes, grain crops and many others; the nematode disease of these has long since been ascribed to a single variety of the stem nematode - Anguillulina dipsaci var. communis Steiner et Scott, 1934 Ditylenchus dipsaci--(Kuehn) Filipjev, 1934.

CONTROL MEASURES FOR ONION NEMATODE

One of the more essential measures is crop rotation with selected resistant crops, in which the onion and other possible subsistence plants of the nematode (garlic, tomatoes and peas) must not be sown in the same field before the expiration of 1-2 years. This can be accomplished easily on sovkhoz and kolkhoz [state and collective farms] fields, since the number of worm-resistant plants is fairly large.

Of utmost importance is also seeding of uninfested seed material so as not to add to the soil a new supply of the onion nematode. The old supply of worms can be eliminated by efficient crop rotations and careful clearing of fields of post-harvest onion refuse. Selection of seed bulbs is accomplished best during harvesting. The appearance of infested plants immediately upon their extraction from the ground is so typical that they can be picked out without any difficulty. The remaining few contaminated bulbs must be removed by additional sorting before that bulbs are stored and again just before planting. Thus, thegarden onion reserved for seed can be cleared fully. It is not so simple with the seed onion. It must definitely be cleared during harvesting, as its sorting later on is very difficult. Experience proves that infestation of theseed onion after winter storage is frequently 1-3%, and dehelminthing of bulbs can be accomplished completely only with the aid of wet thermic treatments. Experiments have revealed that to achieve this objective, it is most desireable to apply the following temperatures and exposures:

45-46° C for 15-10 min.

50-52 " 10-5 "

55-57 " 5-3 "

The temperatures and exposures indicated are quite sufficint for dehelminthing, and they often kill the nematodes together with the bulb, if it is badly infested; one naturally, need not regret the loss of infested bulbs, for they would produce no yield anyway. Wet thermic treatment before planting has no ill effect on the growth of healthy plants. Laboratory and greenhouse experiments at Petrodvorets have on the contrary, shown that growth and productivity have benefited from thermic treatment. Results of wet thermic treatment of the seed onion grown in 1939 in a Petrodvorets greenhouse are cited in table 9. Each plant grew to full maturity in a separate pot filled with soil sterilized for nematodes. Sterilization was accomplished by heating the soil for about an hour at 60-80° C. The bulbs collected at the end of the experiment lay in storage the winter of 1939-40 without producing and waste. [Begin p. 544]

Table 9.

Influence of wet thermal treatment on growth of seed onions grown in sterilized soil at Petrodvorets in 1939

Nos. in consec. order	Temperature (°C)	Exposure (in minutes)	Number of bulbs	Plants derived	Yield (in bulbs)	Bulb diameter of new crop (in cm) From - to	Average
1	45-46	10	3	2[1]	5	1--1.75	1.5
	Control	--	3	3	5	1.5--2	1.75
2	50-50.5	10	5	5	16	1 --2	1.75
	Control	--	6	5[1]	16	1--2	1.75
3	52	5	5	5	23	0.5--1.75	1.5
	Control	--	4	4	9	1 --2.75	2
4	57	3	6	6	21	1--2,75	1.5
	Control	--	3	3	7	0.5--2	1.5
5	67	1	5	5	12	1--2	1.5
	Control	--	5	3[1]	6	1.5--2.25	1.75
	Total		45	41	120		

[1] Fusarium and rose rot infection was observed in all cases of plant destruction.

Similar results were obtained under field conditions in Kichanzino in 1939, where thermal treatment of seed onions was accomplished shortly before planting at a 42-45° temperature and 2-hour exposure. The experiment was conducted in April and repeated twice on test lots measuring 9.5 m in length and 1 m in width. Three hundred and fifty seven bulbs were planted in the test lot in 3 rows parallel to its long axis. Results were evaluated by means of external inspection of the plants in each middle row. The plants collected were sorted into groups of healthy, diseased, doubtful as to infestation and others.

Specimens infected by fusarium, gray mold, and injured by the onion fly and other pests were included in the last group; immature plants, too, were included in this group. The results of counting and weighing of experimental plants by groups are cited in table 10. Its analysis is convincing that wet thermal treatment had failed to exert any great influence on the weight of the yield gathered; the plants produced an average 316 gr drop in weight per test lot, and reduced the number of bulbs by 30. This can be explained by the extremely long exposure of the seedling to wet thermal treatment which can be greatly reduced without impairing dehelminthing results. A decreased exposure should raise considerably the general productivity of the plants treated. The experiments conducted, naturally, require checking on a large, industrial scale, but there is no doubt as to the feasibility of using the wet thermal method in treating seed onions against the onion nematode.

Apparently, it is also entirely possible to apply the wet thermal treatment in dehelminthing onion seed (of the chernushka onion) reserved for sowing. From the unpublished experiments of T, F, Nikitina, conducted under laboratory conditions at the Gorki Regional Experimental Station for Field Husbandry, it can be concluded that dehelminthization of the "chernushka" onion by the wet thermal method produces abundant germination fo these seed. In field experiments at Kichanzino, [Begin p. 545] this sort of treatment of the "chernushka" onion also produced positive results (table 11). The experiment was repeated twice on test lots measuring 9.5 m in length and 1 m in width. Altogether, experiments were conducted on 114 m^2. On each test lot, 47.5 gr of onion were seeded in three rows, parallel to its long axel. Seeding was carried out in 1939; experimental results were evaluated from August 21 through September 2nd. One row of each test lot was selected for calculation. Due to dry weather in the first half of the summer, germination was very protracted and the plants began to sprout noticeably only after the torrential rains of July 6-8th which were accompanied by chilly weather. The rains caused the mass movement of nematodes and their mass infestation of onions. At harvest time the general infestation of the seed onion was fairly heavy, but considerably less than that of the garden onion (table 10), which must be explained by the relatively late infestation of the seed onion.

Due to late planting of the seed onion, the plants were not quite ripe at harvest time, and, therefore, they were weighed with the leaves. On the treated test lot, the average total weight of plants was 157 gr. more than that of control plants: yet the number of plants harvested was by 52 less. It is to be expected that by reducing the time period for preliminary wetting, plant growth will prove considerably better than that of controls. Unfortunately, the problem as to whether or not the treatment kills the nematode within the plant remains an open qestion. However, by analogy of

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Table 10.

Influence of thermal treatment on growth of seed onion and on its infestation by onion nematode as per field observations at Kichanzino in 1939

Test lot	Repetition	Number of bulbs collected				Weight of bulbs (in kg)			Total bulbs collected	Weight (in kg)	Average of one test lot in three varieties					
		Healthy	Diseased	Doubtful	Others	Healthy	Diseased	Doubtful & Others			Total bulbs collected	Weight	Number of bulbs: Healthy	Number of bulbs: Sick	Weight of bulbs (in kg): Healthy	Weight of bulbs (in kg): Sick
Control...	I	44	106	19	25	1.702	2.955	1.162	194	5.819						
	II	9	157	15	19	0.222	3.619	0.445	200	4.286						
	III	52	77	27	39	1.380	2.902	1.094	195	5.376	196	5.160	35	113	1.101	3.159
	Total	105	340	61	83	3.304	9.476	2.701	589	15.481						
Heating in water at 42–45 C for 2 hours...	I	90	64	25	15	2.100	1.980	0.550	194	4.630						
	II	4	129	17	25	0.163	4.845	0.563	175	5.571						
	III	35	79	14	--	0.823	3.056	0.452	128	4.331	166	4.844	43	91	1.029	3.294
	Total	129	272	56	40	3.086	9.881	1.565	497	14.532						

Remarks. One average row of each test lot was used for analysis in all three repetitions. Analysis was made on September 9th.

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T a b l e 11.

Influence of dry and wet thermal treatment of (dark) onion seed on their growth and infestation by the onion nematode under field conditions at Kichanzino in 1939

order	Test lot	Date of observation		Number of plants: Healthy	Diseased	Doubtful	Other	Weight of same plants (in kg): Healthy	Diseased	Doubtful	Total plants collected	Weight (in kg)	Average per test Lot in three variants: Number of plants	Their weight (in kg)
1	Control.......	Aug. 21	I	322	174	81	19	0.530	0.389	0.126	596	1.045		
		Aug. 21	II	430	286	73	16	0.777	0.956	0.206	805	1.879	770	1.784
		Aug. 21	III	660	140	50	59	1.650	0.575	0.204	909	2.429		
2	Dry heating for 24 hours at 50 C.........	Aug. 21	I	380	119	117	24	1.018	0.548	0.324	642	1.886		
		Aug. 21	II	253	194	57	19	0.575	0.737	0.178	523	1.090	616	1.773
		Aug. 21	III	504	64	49	66	1.430	0.332	0.180	683	1.942		
3	Dry heating for 24 hours at 60 C......	Aug. 21	I	630	104	70	24	1.283	0.694	0.345	842	2.340		
		Aug. 21	II	222	185	64	14	0.454	0.705	0.160	485	1.319	659	1.822
		Sept. 2	III	456	82	51	61	1.254	0.340	0.209	650	1.808		
4	Preliminary steeping in water at 30 C for 4 hours, then heating in water at 50 C for 10 minutes........	Aug. 21	I	524	177	65	26	1.401	0.722	0.191	792	2.314		
		Sept. 2	II	224	259	85	16	0.482	0.775	0.234	584	1.491	718	1.941
		Sept. 2	III	484	174	62	57	1.035	0.767	0.215	777	2.017		

action exerted by high temperatures on other nematode species, particularly on that of wheat - Anguina tritici (Steinbuch), it can be assumed that the temperatures indicated in table 11 will kill the worms.

We find it impossible to dwell on all experiments and observations conducted for the purpose of investigating measures to combat the onion nematode, because most of them: for instance liming of soil, different varieties of of fertilizers, testing of microelements, different seeding dates, experiments in turning over layers, [oberot plasta] and others, have produced no positive results, and the experiments and observations which did produce results have been described above. Nonetheless, there is an experiment which cannot be left unmentioned; it was conducted in Kichanzino for the purpose of clarifying in what form worms are when they pass through animal intestine and whether or not they might be distributed with manure, The author had taken under observation two sheep which for 2 days (August 5 and 6, 1940) had been fed heavily infested onions. In this settlement, many farmers use infested onion for animal feed, particulary for sheep and goats. Some of them preserve also dry onion leaves as winter feed for cattle. Infested onions intended for feed were picked from plants of the experimental lot. These were mixed with cabbage leaves and weeds, but the sheep preferred the onions. Excretory analysis have shown that the large majority of worms had been completely digested in the intestines. Altogether, 37 nematodes were found in excretions, although the sheep had been swallowing them by the million. Three of them were observed to move the head end of the body very slowly and briefly; an attempt to revive the worms by transferring them to pure water ened in failure. This experiment justifies the assumption that the worms cannot be distributed with manure. But it must be kept in mind that manure may always contain a certain amount of undigested feed, and, to ensure full onion nematode sterility of manure, care must be taken that feed is well digested. Since nematodes cannot survive fermentation, well fermented manure becomes entirely harmless as far as their distribution is concerned.

COMPARISON OF ONION NEMATODE POPULATIONS GROWN ON DIFFERENT PLANTS

Assuming that food properties cannot fail to influence the organism of worms, we conducted a thorough morpho-anatomic study of onion nematode populations grown of different plants. For characterization of each population, we usually selected 50 specimens form the phase under consideration. Each specimen was measured and the dimensions obtained were recored accoriding to the Cobb [Kobb] formula. In addition, measurements were taken of the spine [igla], the distance between the vulva and the posterior end of the body in females, the spicules and the redferrule [rulek], distance between bursa and tip of tail in males, and likewise size alpha (relation of body length to length of tail). Measurements were ta ken chiefly of fixed material (4% formalin); a few measurements were taken also of live material. It must be noted that the nematodes utilized for measurement were not collected at exactly the same time.

The August 1940 onion samples were not fixed; hence, to measure onion nematode populations, it was necessary to use specimens collected in August-September of 1939. Populations from tomatoes and peas, however, were collected on 20-22nd August, 1940.

When populations of the onion nematode grown on different subsistence plants are compared, it can be seen that the onion population is composed of individuals considerably larger than those of the tomatoe population, and of just a little larger ones than those of the peas population (table 12; fig.5). The peak of the variation curve in nematodes extracted from onions lies within the limits of 1400-1500 microns, dropping sharply on both sides. [Begin p. 547] The curve for females (60 specimens) and that for males (40 specimens) look almost alike. In the onion population, larvae of the fourth stage also have large dimensions, possessing an average of 1100 microns in length and 23 microns in width taken of 50 measurements. Individual variation in their length rests within the limits of 950 to 1300 microns in width, with minimum dimensions measuring 60 x 30 and maximum 111 x 33 microns.

The population of the onion nematode grown in tomato tissues reached an average 1190 microns in length and 30 microns in width in females, and a corresponding 1150 x 24 microns in males. The dimensions of females are alpha==40, beta==6.6, gamma==16, and in males correspondingly: alpha==49, beta==6.7, gamma==15. In the tomato population, larvae of the fourth stage have an average of 885 microns length and 22 microns in width. Minimal larvae dimensions reach 770 x 20 and maximal 1000 x 25 microns. The size of eggs is almost the same as in eggs of the onion population, having a 78 x 32 micron average (out of 50 measurements).

The pea population is characterized by larger dimensions than that of the tomato population, and, in this respect, it does not differ from the onion one. In 25 females extracted from peas, the average body length equaled 1460, and the width 32 microns; in females: alpha==46, beta==7.3 and gamma==16. The males are a little smaller and average 1349 microns in length and 25 microns in width (24 measurements), in males, alpha==55, beta==7 and gamma==16.

Thus, as regards size alpha, and the total dimensions of male and female bodies, the pea population is undistinguishable from that of the onion one. Fourth stage larvae of the pea population vary from 880 to 1220 microns in length (average 1109), and from 20 to 25 microns in width (average 23). Consequently, the dimensions of the pea population do not differ from those of the onion population. Since we lack details as to the localization of the pea population in pea tissues, [Begin p. 549] it is impossible to determine the dimensions of their eggs, provided they do hatch eggs in this plant. Dimension similarity in the onion and pea populations is quite remarkable, if the worms actually multiply in pea tissues.

Worms extracted from radishes, mustard, cabbage, beets, lentils, vetch, flax, tansy, tobacco, eggplant, potatoes and dill are, in point of dimensions, very close to specimens of the onion population. Although found in many plants, their number was very small.

Of the list of plants which attract the nematode, the greatest attention was paid to the fodder turnip and the turnip. The females extracted from turnip averaged 1315 microns in length and 26 microns in width. The males were somewhat smaller attaining (of 21 measurements) an average of 1273 microns in length and 23.6 microns in width. In females, alpha 41.6, beta 6.2, gamma 14.7, and in males, alpha 50.3, beta 6.4, and gamma 13.9. The length of females varied from 1000 to 1700, and in males - from 900 to 1600 microns. The great variation in worm dimensions indicates heterogeneity of nematodes found in turnips. It is entirely probable that this phenomenon is due to the absence of conditions in turnip tissues essential to the propagation of the onion nematode, and indicates that the worms had climbed on this plant from without and at different times.

Dimension analysis of nematodes from fodder turnip (17 females and 13 males) produced the same results. Average female dimensions equalled 1232 x 27 and those of males 1310 x 22 microns. The length of females varies from 880 to 1517 and that of males from 1100 to 1628 microns. Average in females alpha = 45, beta = 6.2 and gamma = 15; in males alpha = 58.2, beta = 6 and gamma = 14. Body dimensions of the nematode are as heterogeneous as in the preceding case. This, obviously, can be attributed to the fact that the worms had developed in plants other than the fodder turnip. [Begin p. 550]

The materials cited reveal that a subsistence plant leaves its imprint on the parasite developing within its tissues. The onion nematode is afforded a more favorable habitat in the tissues of onions and it produces a population that is characterized by maximal dimensions, compared to populations developed on other plants.

Table 12.

Comparative dimensions of onion nematode specimens from populations grown on onions, tomatoes and peas, at Kichanzino in 1939-1940

			Dimensions of nematodes (in microns)				
			Length of body	Width of body	Alpha	Beta	Gamma
Aug. 20 1940	peas	♀♀	1110-1758 (1460)	25-45 (32)	37-59 (45.9)	6.1-8.4 (7.3)	13-19.4 (15.9)
		♂♂	1210-1517 (1349)	20-30 (25)	40.3-74 (55)	6-8.1 (7)	14.2-17.5 (16)
Aug. 20 1940	Tomatoes	♀♀	935-1320 (1190)	25-37 (30)	27.1-49.7 (39.7)	5.6-8.7 (6.6)	12.4-24.6 (15.9)
		♂♂	950-1300 (1149)	16-28 (23.7)	35.7-62.0 (48.7)	3.8-8.3 (6.7)	13.1-17.3 (15.2)
Aug. 15 Sep. 2 1939	Onions	♀♀	1130-1924 (1440)	30-43 (34)	34.8-55.4 (42.5)	6.7-8.6 (7.6)	14-20 (16.7)
		♂♂	1190-1685 (1405)	20-30 (25.5)	44.8-74.2 (56)	6.2-8 (7.2)	14-18.6 (16.0)

Remarks: average sizes are cited in parentheses.

In contrast, nematodes in tomatoes have a less favorable habitat and this fact is markedly reflected in their sizes. Eggs are exposed to the least variation and are almost of the same size as the eggs of the onion population.

900 1100 1200 1300 1400 1500 1600 1700 1800 1900

Fig. 2. Variation in body length in onion nematode populations reared on different subsistence plants.
Line with highest peak - length of female body, with a less high peak - length of male body; solid line denotes onion population, broken line - tomato population, line of dots and dashes - the pea population; figures beneath denote length of body in microns.

Influence of environment manifests itself first of all in the total dimensions of the worms, but in individual cases, significant variation is observed in separate organs. Thus, in the pea population, the length of the tail, which can change from a pointed one to a dull one, varies noticeably.

Once, among several thousand nematode specimens with normally developed pointed tails, one male was observed with an absolutely dull tail (table II, 5). Finally, this influence can extend to the bulbus and, apparently, to other organs. In nematodes extracted from turnips, it was observed that the bulbus changed its oblong form to an almost spherical one. In most nematodes collected from turnips in August 1939, bulbus dimensions were 16 x 11 microns. In the onion population it is considerably more elongated and averages 20 x 10 microns.

Trans. A. 527
From the Russian by
R. Adelman

Murav'ev, V. P.

Izmenchivost' Virulentnosti Mokroi Golovni
v Zavisimosti ot Prokhozhdeniia Tsikla ee
Razvitiia cherez Raznye Sorta Pshenitsy

[Variability of the virulence of stinking smut
in relation to the passing of its developmental
cycle through different varieties of wheat]

Doklady Akademii Nauk SSSR, June 11, 1954
Vol. 96, No. 4, P. 857-859   511 P444A

Variability of the virulence of stinking smut in relation to the passing of its developmental cycle through different varieties of wheat

In the fall of 1951, seed of winter wheat were inoculated with the spores of stinking smut (<u>Tilletia tritici</u>) before they were seeded. The spore stock was entirely homogenous; it was obtained from wheat spikes also infected as a result of spore inoculations in the preceding vegetative period.

We gathered separately spikes infected by smut from five varieties (belotserkovskaia 200, L'govskaia 3612, Khar'kovskaia 917, Liutescence 17 and Ukrainka) and extracted from them spores of stinking smut which had completed their cycle of development in one vegetative period in different varieties of winter wheat.

To determine whether or not the passing of smut through different varieties had had an effect on its properties, and to ascertain the character of this effect, we, in the fall of 1952 prior to seeding, inoculated spores into seed of the same varieties of wheat from which the spore stock had been obtained, and, in addition, three other varieties, namely: Lesostepka 75, Erythrospermum 15, and Liutescence 9. Thus, experiments were conducted on 8 varieties of wheat characterized by sharply varying resistance to smut. This was demonstrated decisively by infection indicators obtained as a result of calculations made at the end of the vegetative period in 1953 (see table 1).

Tablo 1.

infection of winter wheat by smut that had passed through different varieties (percentage of infected spikes)

Varieties tested	Varieties from which spores were obtained					
	Belotserkovskaia 200	L'govskaia 3612	Khar'kovskaia 917	Liutescence 17	Ukrainka	Average
Belotserkovskaia 200	14.9	12.8	15.0	15.9	12.7	14.3
L'govskaia 3612	40.6	42.7	41.2	36.3	40.5	40.3
Khar'kovskaia 917	45.8	54.7	57.7	44.8	58.4	52.3
Liutescence 17	52.5	57.3	63.3	49.8	54.3	55.4
Lesostepka 75	75.0	69.6	65.1	72.5	58.0	68.0
Erythrospermum 15	61.3	70.3	69.9	73.9	68.3	68.7
Ukrainka	77.0	71.2	74.1	55.2	67.1	69.0
Liutescence 9	71.5	60.1	71.2	81.1	64.1	69.6

Belotserkovskaia 200 proved the most resistant to stinking smut, which coincides with its well-known industrial characteristics. The data cited in table 1 demonstrate fully that the relative infection of the varieties in this experiment, determined by percentage of spike infection, fluctuates greatly when seed is inoculated with spores derived from different varieties of wheat. Besides, the range of infection fluctuations within the limits of each variety is less considerable in cases of relatively resistant varieties and more so in cases of susceptible varieties. Thus, in the Belotserkovskaia 200 and L'govskaia 3612 varieties, the difference between the maximal and minimal infection - Ukrainka and Liutescence 9 - the difference is 21.8 and 21.0% respectively.

Table 1 indicates that regardless of which smut was inoculated, Belotserkovskaia 200 and L'govskaia 3612 varieties hold first and second places in resistance to smut. Third and subsequent places are held by different varieties; thus, Lesostepka 75, Liutescence 9, Khar'kovskaia 917, and Ukrainka are found in fifth place. With respect to the last variety, it can definitely be said that the appraisal, which it received during an infection by smut that came form the Liutescence 17 variety, did not correspond to the well-known characterization of Ukrainka as one of the most susceptible varieties of winter wheat. Thus, the relative susceptibility of varieties, and the place occupied by a given variety among a number of varieties tested, depend on the spore material on which the degree of resistance was tested.

The data cited above indicate that smut changes after passing through different varieties. The very important property that changes in particular is smut virulence. This circumstance attracted the attention of the phytopathologist V. N. Shevchenko. It is a circumstance that must be taken into consideration in the work of selection and development of resistant varieties. To obtain comparative appraisals, it is necessary to use spore material of uniform composition for spore inoculation. To obtain an appraisal of variety resistance to smut for industry, it is necessary that, for the preparation of spore material, smut infected spikes be collected in the region for which the varieties under appraisal are designated, and that varietal environment be taken into consideration.

By analyzing data on the degree of infection caused by smut obtained from different varieties, and by ascertaining the variability of its virulence, we can establish the character of the variability of smut virulence. For this purpose, we will compare the susceptibilty of varieties with the virulence of smut which has passed its cycle of development through a given variety (see table 2).

The degree of susceptibility in table 2 was takenfrom the last graph of table 1. For the virulence degree of smut form the given variety we took themagnitude of infection caused by inoculation of its spores in all of the other 7 varieties. From an appraisal of this sort, the virulence of smut that had passed through the Belotserkovskaia 200 variety proved maximal: it caused a 60.5% infection in the rest of the 7 varieties. The minimum indicator of virulence (50.7%) was found in smut from Ukrainka, the most infected variety.

Thus, one can arrive at the conclusion that the greater the susceptibility of the variety, the less nocuous is the virulence of smut which has passed through the given variety. So, the correlation coefficient $r = -0.91 \pm 0.08$, i.e. the reversible correlation, is sharply pronounced and has been fully proved mathematically.

Thus, if the cycle of smut development was consummated in a resistant variety, then its virulence increases. Such a rule, proved experimentally in the case of stinking smut of wheat, undoubtedly is true also with respect to causal agents of other plant diseases.

An adequate adaptation of the parasite to varieties is one of the reasons for the apparent "loss of resistance by a variety". "Apparent" - because in the given case, the phenomenon taking place is of a different order: the variety can fully retain its resistance, but the reproduction of the resistant variety will contribute toward an accumulation of a more virulent parasite in the surrounding area.

Trans. A. 528
From the Russian by
R. Adelman

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Krivykh, F. P.

Pochva s Parovogo Polia kak Bakterial'noe Udobrenie

[Soil from Fallowed Field as Bacterial Fertilizer]
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SOILS FROM FALLOWED FIELD AS BACTERIAL FERTILIZER

(Submitted by the Plant Breeding Section of the All-Union Lenin Order Academy of Agricultural Sciences named for V.I. Lenin)

The modern Michurin teaching concerning plant nutrition is based on the close inter-relations between higher green plants and soil microorganisms. Cultivated plants cannot develop normally when they lack the appropriate microflora. At present, it is established that each species of higher plants has its specific, coresponding groups and races of microorganisms. It has long been known that a fallowed field is the best predecessor of many crops. There is no doubt that here favorable conditions for plants are created not only by means of water and food reserves, but also by variation in the qualitative and quantitative composition of microflora. A fallowed field contains considerably more microorganisms than virgin soil or a potato field (table 1).

Table 1.

Amount of bacteria (in millions per gram of absolutely dry soil	
On unfertilized fallow	1641
" potato field..........................	1106
" virgin soil............................	723

The numbers cited show that the amount of bacteria in virgin soil is less than half that on a fallowed plot. It must also be noted that the activity of aerobic bacteria proceeds more intensively on a fallowed plot.

Not only the number of microorganisms decreases in virgin soil, waste land, and in the layer under perennial grasses on structureless soil, but their activity, too proceeds in a direction other than that in a fallowed field. The introduction of soil from fallow effects a rapid change in the composition of microorgainsms and, thus, causes that inhibit the normal development of plants can be eliminated.

For the purpose of investigating this problem, virgin soil was plowed on August 25, 1949. At this time, the biological processes in soil were already ceasing. Seeding of winter rye was accomplished the same day. The experimental scheme was: 1) control; 2) test plot fertilized with superphosphate; 3) test plot fertilized with soil from a fallowed field (calculated at 4 centners per ha) and with superphasphate (2 c per ha). The fertilizers were introduced into the rows together with the seed.

On the fertilized test plots sprouts appeared on September 1-2nd, yet on the control plot only on September 10th. Besides, most seeds on the test plot produced no sprouts whatever. On September 14, when germination was evaluated, it was found that the test plot fertilized with soil from the fallowed field had produced 252 plants per square meter, the test plot fertilized with superphosphate, 140, and the control plot only 56. The sprouts on the control plot were characterized by poor growth. The following year, only the plants on the test plot fertilized with soil from the fallowed field developed normally; [Begin P. 17] they flowered normally and produced seed. On the other test plots, rye developed poorly, it managed to flower, but produced no seed.

Evaluation are cited in table 2.

Table 2.

Variant	Weight of plants from 4 m^2 in air-dry state (in gr)	Height of plants (in cm)
Control....................	156	78
Test plot fertilized with superphosphate	324	91
Test plot fertilized with soil from fallowed field..........................	1368	116

On the test plot fertilized with soil from the fallowed plot, plants developed much better than on the control plot. Fertilizing with superphosphate changed the situation but little.

This experiment conviced us of the expediency of utilizing soil from a fallowed field as bacterial fertilizer. In subsquent experiments, field germination of seed increased considerably and plants developed better when soil from a fallowed field was added.

Special experiments conducted to test the effectiveness of the application of from a fallowed field upon field germination of seed (soil was introduced together with seed) have shown (table 3) that in many cases it can increase by 14 and even by 20% [1].

Table 3.

Crop and variety	Variant	Seedlings from 600 seeds	Difference	Average field germination (in %)
	Experiment of 1951			
Udarnitsa wheat	Control.........	476		78
	With introduction of soil from fallowed field.	504	28	84
Sibirskii flax	Control.............	383		63
	With introduction of soil from fallowed field......	463	80	77
Tulunskow millet 39/9	Control..................	380		63
	With introduction of soil from fallowed field......	473	93	76
Foxtail millet	Control..................	311		52
	With introduction of soil from fallowed field......	413	102	69
	Experiment of 1952			
Tulunskoe millet 39/9	Control..................	275		46
	With introduction of soil from fallowed field	310	35	52

[1]F. P. Krivykh. Problem of Germination of Seed. Zhurn. "Seloktsiia i Semenovodstvo" No.3, 1953.

To increase the biological activity of soil taken from a fallowed field, bacteria-breeding nurseries were established. On small plots measuring 200-300 m^2, 500-600 tons of manure were applied according to per-hectare estimates; it was plowed under and the plots were maintained in a state of pure fallow, with plowing being repeated 3-4 times during the summer. In the summer the manure decomposed into a chernozem-like mass. [Begin P. 18] The following year the soil from the nursery was applied as a fertilizer for grain and other crops. This soil contained not only a large amount of microorganisms, but was also richer in nitrogen, phosphorus and potassium.

Bacterial nurseries must be established either near cattle yards or near the fields to be fertilized.

In the first instance, the dosage of manure fertilizer can be increased to 1500-200 tons per ha, utilizing the nurseries as manure storage (the manure is applied at intervals).

If nurseries are organized near the fields to be fertilized, then manure can be applied at the rate of 200 to 500 ton per-hectare. One hectare of the bacterial nursery can produce from 1 to 3 thousand tons of soil to be used as fertilizer. The amount of fertilizer derived form one hectare depends on the depth at which the soil is taken - the arable horizon from one hectare weighs about 3000 tons. The manure applied must be plowed in and harrowed immediately, and later in summer, the bacteria-breeding nursery must be kept in a mellow and moist condition (with 4-5 treatments).

The nursery can be established either in the fall or spring. In well prepared mursery soil, the manure must decompose completely and turn into a mass resembling chernozem.

We are citing some experimental data of the Irkutsk Agricultural Institute, the Balydaev Experimental Station, and partial data of industrial experiments.

Experiments of the Irkutsk Agricultural Institute. Soil from a fallowed field and from the bacterial nursery was applied for wheat, barley, oats and potatoes. Data on productivity are cited in table 4 (in centners per ha).

Table 4.

Variant	1952		1953	
	Wheat after perennial grasses	Barley after potatoes	Oats after potatoes	Oats after potatoes
Control...........	13.33	13.35	26.25	27.60
With soil from fallowed field 2 tons per ha..............	15.22	16.22	--	29.81
With soil from nursery 2 tons per ha..............	15.83	18.19	--	31.45
Same, 20 tons per ha..........	--	--	37.09	--
With humus, 20 tons per ha....	15.68	18.51	33.33	--

In the experiments cited all fertilizers were applied in pre-seeding tillage and were plowed under with goosefoot cultivators. Application of soil from a fallowed field produced an increase in yield in all cases; the strongest action was exerted by soils from the bacterial nursery.

Table 5.

Variant *	1952		1953	
	Potato yield (in c/ha)	Increase (in c/ha)	Potato yield (in c/ha)	Increase (in c/ha)
Control...................	177.0	--	205.44	--
With humus, 10 tons per ha	204.0	27.0	219.55	41.11
With soil from nursery, 10 tons per ha..........	238.0	61.0	245.76	40.32
Same + phosphorobacterin..	--	--	269.10	63.66
Phosphorobacterin	--	--	223.02	17.58

*Fertilizers were applied in holes when potatoes were planted.

In experiments with potatoes, the best results were also obtained when bacterial nursery soil was applied, and when potato tubers were given a supplementary treatment with phosphorobacterin (table 5).

Experiments of the Balydaev Experimental Station. At the Balydaev Experimental Station, activated soil from a fallowed field was used in 1951. For this purpose, the soil was kept in a moist and loose state in a warm compartment for several months, and then applied in pre-seeding disking of soil. The experiment was conducted on a timothy bed [for wheat]. Results are cited in table 6.

Table 6.

Variant	Wheat yield (in c/ha)	Increase (in c/ha)
Control	24.17	--
With manure, 40 tons per ha	28.14	3.97
With soil from fallowed field, 6 centners per ha	30.04	5.87
With soil from nursery, 6 c/ha	30.24	6.07

The 1952 and 1953 experiments produced less favorable results, but the in crease in the yield of wheat was, nonetheless, 2.6 and 3.9 centners per ha (table 7).

Table 7.

Variant	1952		1953	
	Yield (in c/ha)	Increase (in c/ha)	Yield (in c/ha)	Increase (in c/ha
Control	27.9	--	11.13	--
With soil from fallowed field 1.5 centner per ha	--	--	13.72	2.65
With soil from fallowed field + azotobacterin	--	--	14.23	3.10
With soil from nursery, 3 c/ha	30.5	2.6	---	--
" " " " 6 c/ha	30.7	2.8	---	--
" " " " 20 c/ha.	31.8	3.9	--	--

Here, too, the application of soil from the fallowed plot combined with azotobacterin produced the best results.

Very good results were obtained also when seeds were treated with a liquid solution of soil from a fallowed plot.

Treatment of seed was carried out as follows. For every 100 kg of seed 1-2 kg of soil from a fallowed field was used; this soil was disolved in 30 liters of water and the solution obtained was used to steep the seed (the same as it is done in a case of vernalization). After 24 hours, the seed was dried and sown. The results are cited in table 8.

Seed treated with a solution of soil from a fallowed field produced a yield increase of 3.16 centners.

Analogous experiments conducted at the Irkutsk Agricultural Institute confirmed the prospects of this method.

<u>Experiments on kolkhozes [Collective farms]</u>. In 1951, agronomist V. Azhunov of the "Put' Il'icha" kolkhoz, Baiandaev aimak*, used granulated soil from a fallowed plot to fertilize spring wheat seeded after winter rye in a field plowed in the autumn for spring crops. [Begin P. 20].

The soil was used as fertilizer in pre-seeding tillage at 8 centners per ha. On the control plot, he obtained a yield of 16 centners per ha, yet on the plot fertilized with soil from a fallowed field, 20 centners per ha.

In 1952, tovarishch Anan'ev, initiated an analogous experiment with spring wheat of the Liutescence 62 variety. On the "Komintern" kolkhoz, Kuitun Region soil was taken from farm fallow and applied under pre-seeding cultivation. The results of these experiments are cited in table 9.

The data cited show that particularly good results were obtained when PK [potassium phosphates (?)] was added to soil from a fallowed field.

Table 8

Variant	Wheat yield (in c/ha)
Control (dry seed)	28.05
Seed treated with pure water	26.27
Seed treated with solution of soil from fallowed field	31.21

[*Localism for "region".]

Table 9.

Variant	Yield (in c/ha)	Increase (in c/ha)
Control.................	14.50	--
With soil from fallowed field 2.5 tons per ha	17.50	3.0
With humus, 10 tons per ha	16.00	1.50
With soil from fallow field, 2.5 tons/ha + PK	19.75	5.25

CONCLUSIONS

1. Soil from a fallowed field can be utilized as bacterial fertilizer. Such soil exerts a favorable influence upon plants, thanks to the required groups of microorganisms within it. Small doses (4-6 centners) of such soil seeded together with seed considerably increase the yield of grain and other crops.

2. The effectiveness of soil from a fallowed field increases markedly if it is first exposed to warmth either in a warm chamber or in the sun for several weeks. Hence, it must be taken from fallow located on southern slopes which are exposed to warmth, from plots rich in organic substances or fertilized with manure.

3. Soil from a fallowed field cannot be compared with other bacterial fertilizers, it must rather be used to supplement others. The combined use of soil from a fallowed field and other bacterial preparations is more effective than their application separately.

4. Fallowed soil produces the best effect when it is introduced in the soil together with seed. When it is applied with a cultivator, then the amount of soil per hectare must be increased up to 2 tons; it is best plowed under with disk tools.

5. Soil from a bacteria-breeding nursery is most effective because, in addition to a large amount of needed microorganisms, it contains many nutritive substances easily accessible to plants. Therefore, the establishment of such nurseries must be considered as expedient.

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PLANT PHYSIOLOGYY.

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Matskov, F. F. and Podrazhanskaia, B. S.

Stimuliatory Posta kak Mikroudobreniia.

[Growth Stimulants as Micro-Fertilizers].

Doklady Akademii Nauk SSSR, Apr. 21, 1954
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GROWTH STIMULANTS AS MICROFERTILIZERS

Submitted by Academician A. L. Kursanov

February 26, 1954

In experiments conducted in 1948-1950, it was demonstrated that introduction in soil of very small amounts of some organic growth stimulating substances, such as heteroauxin, a-naphthyl acetic acid (AHY), 2.4-dichlorphenoxy acetate acid (2.4-DY), in doses from 0.1 to 0.001 mg per kg of soil, increases considerably the yield of the dry mass of plants (1). In addition, the experiments of 1950 revealed that introduction of growth stimulants (together with microfertilizers) into soil furthers the growth and the development of the root system of plants to a higher degree than their surface parts. We cite the results of some of these experiments in table 1.

Table 1.

Results of experiment with oats in Rotmistrov's boxes (plants harvested at 50 days of life)

Experimental variants	Height of surface organs in cm	Length of roots in cm	Weight of dry mass of surface parts		Weight of dry mass of roots		Total weight of dry mass of plants	
			gr	%	gr	%	gr	%
NPK	75.6	50.5	10.90	100.0	4.34	100.0	15.24	100.0
NPK+AHY*	91.0	62.5	12.26	112.4	5.26	121.9	17.52	114.9
NPK+heteroauxin	87.0	57.0	12.80	117.4	5.18	121.6	17.98	118.1
NPK-2.4-DY	87.5	65.0	11.80	108.3	5.30	122.1	17.10	112.2

*0.1 mg per kg of soil.

Table 1 shows that mixing a microdose of AHY with NPK increased the weight of the dry mass of surface organs of 50-day oat plants by 12.4%, and the weight of their roots - by 21.9%; under the influence of heteroauxin, the weight of the dry mass of surface organs and roots increased by 17.4% and 21.6% respectively, and under the influence of 2.4-DY - by 8.3% and by 22.1%.

Thus, on the basis of our three-year experiments, we can assert that the effectiveness of mineral fertilizers increases, if small doses of stimulating chemical preparations are applied together with fertilizers.

We were unable to ascertain how long stimulants introduced into soil continue to exert action, i.e. remain active without undergoing further transformation. Seeking an answer to this question, we initiated an experiment with oats in 1951.

Back in the fall of 1950, vegetative containers were filled with soil (4 kg to a container) to which (pursuant to the experimental scheme) a full nutritive mixture (NPK) in Prianishnikov's norms was added simultaneously with an admixture of microdoses of growth stimulants [Begin P. 1330] (heteroauxin AHY and 2.4-DY) - at 0.1 mg per kg of soil. Some of the containers were filled with pure soil. All containers were divided into two groups, one of which was kept in a little cold vegetation house until spring (i.e. at tempertures below zero), and the other - in a warm greenhouse where temperature was kept at 15-17°.

In the spring, the containers were "refilled", i.e. the soil was removed from them, loosened, moistened and replaced in the same containers. In so doing, mineral fertilizers (NPK) with an admixture of microdoses of growth stimulants were added to the containers which had been filled with pure soil in the fall, as prescribed. From the decription of the experimental scheme, it is obvious that our objective was to compare the action of growth stimulants added to the soil in the autumn with the action of those added in the spring. In addition, we wanted to obtain an answer to the question as to how growth stimulants will alter in soil left for 5-6 months under conditions of negative temperatures (when microbiological processes do not function), and under conditions of room temperature when growth stimulants may be subjected to the action of soil microflora. The results of this experiment are summed up in table 2.

Analyzing the data in table 2, one can draw the following conclusions; the different growth stimulants used in the experiment change during a prolonged stay in soil in various ways. Factors of temperature in premises where soil containers with added growth stimulants are stored, exert much influence upon them.

Heteroauxin introduced in to the soil in the fall, obviously, disappears almost completely by spring of the following year, and, therefore, it does not exert its inherent positive action upon the plants. In contrast, 2.4-DY, if added to soil in the fall, acts on the accumulation of organic matter by plants even better (+19.8%) [Begin P.1331] than if added in the spring (+8.7).

It is true that the yield of grain is higher, if 2.4-DY is added to the soil in spring. As far as AHY is concerned, its stay in soil during the

Table 2.

Influence of season and conditions of domicile of growth stimulants while in soil upon thier activity (results of vegetative experiment with oats in 1951).

Fertilizers	Season when fertilizers added	Storage place of container in winter	Height of plants in cm	Weight of dry mass of straw		Weight of dry mass of grain		Total weight of dry mass of plants	
				gr	%	gr	%	gr	%
NPK	Fall (Sep.30 1950)	Veget. house	101.5	8.25	100.0	6.15	100.0	14.40+0.[illegible]0	100.0
NPK+AHY	Same	Same	112.0	10.10	122.4	6.00	97.7	16.10+0.00	118.8
NPK+ 2.4-DY	"	"	107.0	10.50	127.3	6.75	109.8	17.25+0.95	119.8
NPK+ hetero-auxin	"	"	112.0	8.17	99.0	6.57	106.8	14.74+0.74	102.4
NPK	Spring (Apr.30 1951)	"	111.0	10.85	100.0	8.05	100.0	18.90+0.70	100.0
NPK+AHY	Same	"	118.0	13.15	121.2	9.25	114.9	22.40+1.00	118.5
NPK+ 2.4-DY	"	"	108.0	11.05	101.8	9.50	117.9	20,55+0.78	108.7
NPK+ Hetero-auxin	"	"	112.0	12.82	118.2	9.45	117.4	22.27+0.92	117.8
NPK	Fall (Sep.30 1950)	Green-house	100.0	7.17	100.0	5.40	100.0	12.57+0.12	100.0
NPK+AHY	Same	Same	108.5	9.70	135.3	7.27	134.6	16.97+1.57	135.0
NPK	Spring (Apr.30 1951)	"	110.0	11.35	100.0	8.22	100.0	19.55+1.07	100.0
NPK+AHY	Same	"	110.0	14.17	122.0	10.03	121.9	24.20+0.45	123.7

winter (under conditions of the little vegetation house) did not result in its complete disappearance, but it decreased considerably its positive action upon plants seeded in the spring. This was particularly pronounced in the case of grain yield.

Keeping soil to which AHY has been added under greenhouse conditions does not reduce the positive action of growth stimulants upon oats seeded in this soil.

Conclusions concerning the duration of action of growth stimulants added to soil in the fall are not final, since they are based on experimental data of one year only.

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REFERENCES CITED

[1]F. F. Matskov, B. S. Podrazhanskaia, DAN [Doklady Akademii Nauk] 66 No.5 (1949), 72 No.2 (1950).

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Virusnye bolezni Sel'skokhoziaistvennykh
Rastenii i mery bor'by s nimi

[Virus diseases of agricultural plants
and measures for their control]

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VIRUS DISEASES OF AGRICULTURAL PLANTS AND MEASURES FOR THEIR CONTROL

In the light of decision adopted by the September Plenum of the Central Committee of the KPSS [Communist Party of Soviet Union] on measures for the advancement of agriculture, improvement in agricultural plant protection against diseases and pests assumes great importance.

A significant place among the diseases of agricultural plants is held by virus diseases some of which are distinguished by wide distribution and great perniciousness. Most of these diseases have been well investigated by Soviet virologists. However, the practical measures for their iradication, or restriction of their injurious action, suggested at various times in native literature, have not always been utilized in industry. In connection with the above, there arises a need to study this problem at the present time, focusing particular attention on the theorectical basis of control measures recommended for the principal virus infections.

Virus diseases of agricultural plants, the control of which is of great economic importance, are the following:

1.) For technical crops - control of tobacco mosaic, crown chlorosis of makhorka [Azted tobacco], leaf curl of cotton;

2) for cereals - pupation of oats and mosaic of winter wheat;

3) for fruit crops - psorosis or peeling of bark of citrus plants;

4) for vegetable crops -" stolbur" of tomatoes, pepper and egg-plant; mosaic and "streak" of tomatoes, mosaic No.2 of cucumbers;

5) for potatoes -"stolbur" wilt and wrinkled mosaic, or streak.

The causal agents of these diseases are different viruses whose biological characteristics determine to a considerable extent the epiphytological character of each disease. Hence, conditions for the development of different virus diseases of agricultural plants are dissimilar, and methods for their control must be changed accordingly. The biological differences of the agricultural crops themselves are no less important, and their properties of immunity or resistance to virus diseases often determine the outcome.

Knowledge of the biology of the causal agent of disease and of the agricultural plant which it attacks helps to find means for decreasing substantially the loss caused by disease, and to increase the yield.

The investigation of tobacco mosaic conducted by D. I. Ivanovskii at the close of the past century initiated research in a new sphere of biology - the science of filtrable viruses. Having made the greatest theoretical discovery, D. I. Ivanovskii at the same time took great pains to develop means that would aid in the control of diseases which greatly impaired the quality of raw tobacco. He accomplished a great deal in this respect: an accurate diagnosis of the disease was worked out, the spread of infection through contact was ascertained, [Begin p. 50], and it was demonstrated that the first cases of infection could be caused by retention of infectious remains in the soil, which indicated the necessity of introducing tobacco into crop rotations. It was proved that infection was not transmitted via tobacco seed.

It can be said in substance that D. I. Ivanovskii established the main elements of the epiphytology of tobacco mosaic and determined the principal means for its control which have lost none of their improtance up to now. This tradition of combining theoretical investigations with the practical tasks of agriculture is characteristic also of modern Soviet virology.

The All-Union Institute of Tobacco and Makhorka (VITIM) continued to develop methods for the control of tobacco mosaic in the nineteen-thirties; here, the most important results were obtained by I. P. Khudina.

The biological characteristics of the virus causing this disease complicated its control. The virus of tobacco mosaic is distinguished by an unusually high degree of infectiousness and by very strong resistance to unfavorable action of environment. Light contact of a person's hands, soiled with infectious sap, with the leaves or stems of healthy plants causing microscopic wounds, is enough to enable the virus to penetrate into cells and to cause infection. Having entered the injured cells, the virus multiplies, spreads through the adjacent cells and the vascular system, and then penetrates all organs of the plant. Hence it is natural that trauma producing methods such as thinning of seedlings, planting seedlings in the filed, breaking off suckers and leaves facilitate the rapid spread of the virus even if infection nidi were few at the beginning.

Original cases of infection might be due to penetration of plant roots by the virus from soil containing infectious plant remains. As a result of growth movements, epidermal root cells are likely to be subject to slight injury caused by hard particles of the soil; this, too, creates opportunities for infection. Although the virus that has enetered the root usually remains there without penetrating the surface parts of the plant, there, nonetheless, are known cases of a root infection having turned into a general one. Infection by contaminated soil occurs mostly through the contact of soil with the lower leaves. The most frequent source of first infections is, however, man himself who transmits the virus by hand. It suffices to say that the virus is preserved in smoking tobacco, and that the hands of the smoker may always be soiled with it. Utilization of implements that had already been in use, for instance, hothouse frames, baskets and boxes for the transportation of seedlings to a field, is apt to infect a certain number of plants, unless the implements had been disinfected. Infection contacted from these first sources is later spread by the hands of workers.

The characteristics of epiphytology of tobacco mosaic cited make it clear that the main efforts in reducing this disease must be concentrated on prophylaxis. Hence, the principal task involves - neutralization or destruction of infection nidi. This can be achieved by the introduction of tobacco in crop rotations and by disinfection of equipment with a solution of formalin. If the disease has spread but little, not over 2%, then the infected plants are removed from the plantation.

The most important positive results in mosaic control are obtained by development of resistant varieties. In this respect, recognition is due the VITIM breeder, Prof. M. F. Ternovskii (1950). As a result of crossing Turkish tobacco with Nicotiana glutinosa and of subsequent back crossing of the hybrids with tobacco, he obtained varieties which have inherited virus immunity from N. Glutinosa. Recently he obtained a series of resistant varieties, by intravarietal vegetative hybridization (1951). Resistant tobacco varieties were obtained by the same method at the Institute of Genetics, Academy of Sciences, USSR (Agapova, 1953). By extending the area under immune tobacco varieties, mosaic infection will finally be overcome. This is not the first virus disease [Begin p. 51] the eradication of which on a specific crop is a task to be realized in the near future.

Tobacco mosaic is one of the first virus diseases subjected to research. Other virus diseases have been identified only recently and some have not yet been diagnosed. Therefore it is not surprising that the urgent task of determining the nature of a new disease named top chlorosis and spread in some regions on makhorka plantations has arisen comparatively recently. A. A. Popova was the first to describe this disease and to demonstrate its infectiousness. To develop measures for its control, it was necessary to investigate the causal agent of the disease and its means of spread in nature. For this purpose was organized a complex investigation of the disease in which the Institute of Genetics, Akademy of Sciences, USSR (K. S. Sukhov), the All-Union Institute of Tobacco and Makhorka (S.E. Grushevoi and T.M. Matveenko), the Moscow Station of Plant Protection (G.M. Razviazkina and L.A. Butsevich), and the Lokhvitskaia Experimental Base of VITIM (A. A. Popova and P. M. Diadiuchenko) were participating.

With the aid of an electronic microscope and filtration of infected juice through bacteriological filters, it was established that the causal agent was a filtrable virus with particles of a spherical form measuring about 45 milomicrons in diameter (fig. 1). The disease transmitter, tobacco thrips, was established concomitantly. This helped determine the nature of the disease and to characterize the basic epiphytological elements in the first year of research (K.S. Sukhov, G.M. Razviazkina, L.A. Butsevich). Clear orientation as to the development of protective measures was obtained in the course of the same work. One of these measures is the chemical method of dusting makhorka plantings with DDT dust, and of introducing Benzine hexachloride [GKHTSG] into the soil, under makhorka (S.E. Grushevoi, T.M. Matveenko, A.A. Popova).

At present, top chlorosis of makhorka is one of the well investigated diseases. The control method developed is used widely in industry and produces effective results in raising the productvity of this crop.

In the year 1953 the author of the present article and G. M. Razviazkina established also that the tobacco disease known by the name of "virus top deformity" (S.E. Grushevoi, 1951), was identical with top chlorosis of makhorka. Thus, the information obtained concerning the conditions of development of the disease epiphytosis on makhorka can be utilized also in tobacco culture.

Chemical control of thecarrier of top chlorosis - tobacco thrips - is fully equal to the task of eliminating the serious infection of this crop. But this special measure must definitely be combined with agrotechnival practices increasing plant resistance to disease. In this respect, splendid results have been achieved by leading teams of workers of makhorka growing sovkhozes and kolkhozes. For instance, the team of M.IA. Fedorenko, hero of socialist work (1952), harvests up to 85 centners of makhorka per hectare by using the entire complex of control measures against top chrlorosis and superior agricultural practices. This indicates that the first resolution of the control problem of top chlorosis of makhorka has been satisfactory.

In the year 1936, D.D. Verderevskii described leaf curl, a virus disease of cotton in Turkmen. Later this disease was discovered also in Azerbaidzhan where it was studied by S.N. Moskovets (1951).

The disease manifests itself in sharp depression of plant growth, in lodging of the amin stem and in leaf curl. The damage caused by the disease is considerable. Cotton yield of diseased plants drops sharply. There is a 50% reduction in the number of pods, the technological qualities of the fiber - length and strength - are impaired, and so are the properties of seed - absolute weight, germination energy, and sprouting. [Bogin p. 52]

A small percentage of the disease is transmitted by seed. Its chief method of spreading is, however, transmission by melon and cotton aphids. Permanent virus sources in nature are susceptible weeds, for instance, mallow and rape on which cotton aphids frequently settle in mass. (D.D. Verderevskii, S.N. Moskovets).

Clarification of the basic factors of the spreading and development of the disease made it possible to work out a complex of measures as a result of which leaf curl no longer causes any serious loss in yield. The solution of this problem is one of the indicators of the success of Soviet virology.

In overcoming the harmful action of disease, selection of resistant cotton varieties performed an important role. F.M. Mauer developed Az1, Az29, 2966-1, and other varieties distinguished by a high degree of resistance to leaf curl. These varieties are particularly valuable for their high resistance also to the wide-spread bacterial cotton disease - Gummosis.

Agrotechnics are of great importance in maintaining cotton resistance. In a regime of mineral nutrition of cotton in the regions of disease distribution, an important role belongs to phosphorus fertilizers. Phosphorus is introduced in soil during fall plowing and again in supplementary feeding. To ensure a steady decrease of virus reserves in cotton growing regions, the destruction of carrier aphids and weeds is of great importance.

In our country cereals are attacked by two virus diseases - pupation and mosaic of winter wheat. The distribution of these diseases vary. Pupation occurs chiefly in Siberia, Mosaic in districts of the Voronezh and Rostov Regions. Both diseases have been thoroughly investigated (K.S. Sukhov and A.M. Vovk; V.K. Zazhurilo and G.M. Sitnikova).

Pupation virus attacks mostly oats, yet at times grave epiphytotics are noted on wheat and barley. Rye is practically immune to the disease. In nature, the main reservoir of infection is the dark cicada - Delphax striatella. The virus remains long in the organism of this insect which spends the winter in the nymph phase. After developing wings in the third decade of May [May 21-31], the dark cicada migrates onto sprouts of cereals and selectively concentrates on those of oats. Spreading of infection occurs this time. Following the hatching of eggs, the overwintered generation dies off. Part of the second generation remains in the same cereal fields, yet part of it migrates onto the young crop of late spring millet and oats seeded after a mixed forage crop. The third generation does not attain maturity and goes off to spend the winter in the nymph phase of the third age. The degree of infection of young crops on which last generation nymphs feed, and their number determine the rate of epiphytotics of the following year.

Different oat varieties are highly susceptible to pupation. In cases of early infection, oat plants proceed to tiller incessantly until fall without forming spikes. In cases of late infection, tassels develop, but spikelets as a rule are sterile. There occurs an abnormal development of the ovary which protrudes greatly from the spike. Plants infected in the stage of sprouting are a total loss to yield, they produce neither grain nor straw.

A biological study of the pupation carrier helped to determine the necessary control measures. A radical means of extermination of the dark cicada is deep, late fall plowing of all fields that had been under grain crops in the year concerned. Experiments conducted for many years have shown that 98-99% of larvae of the dark cacada perish in deep plowing. A study of the realm of pupation distribution shows that the virus breeds only in those regions of Siberia where late fall plowing is practiced insufficiently. In regions adjacent to areas where fall plowing is wide-spread or even continuous, pupation is practically absent and there is no mass reproduction of the dark cicada.

[A plate inserted between pages 52 and 53 has illustrations described as follows:]

Fig. 1. Agregate of spherical particals of the virus of top chlorosis of makhorka. x 9000

Fig. 2. Mosaic on leaves of lemon during psorosis [peeling of bark].

As a control measure for pupation, deep fall plowing meets all requirements that could be made in similar cases. This measure is extremely useful even from the viewpoint of grain crop agrotechnics; it calls for no special expenditure of labor or funds exceeding the established agrotechnical quotas, and is efficient at the same time. The growth of mechanization of agriculture leading to steady expansion of fields under fall plowing is the real factor in overcoming the menace of pupation. In connection with the above, the primary task in regions where this disease becomes wide-spread is the thorough practice of deep fall plowing.

In contrast to pupation virus, the virus of winter wheat mosaic does not survive in the carrier which passes the winter in the egg phase, but in winter cereals and primarily in winter wheat. The carrier of the disease is the striped little cicada Deltocephalus striatus (V.K. Zazhurilo and G.M. Sitnikova, 1941; K.S. Sukhov, 1942). Development of epiphytotics of the given year was determined by the degree of infection on fall sprouts of winter wheat. During spring growth mosaic plants have a conspicuous chlorotic coloring. Similar to pupation of oats, these plants, too, have been observed to tiller excessively. Spike formation is late or completely absent. In diseased plants, the drop in yield fluctuates from 40 to 100%.

As a rule, spring wheat is attacked slightly. This is explained by the fact that embryonic and postembryonic development of the striped cicada ends comparatively late, when spring wheat is already in the phase of stem formation. In late infections, the disease loses its noxiousness to a considerable degree. Hence it is particularly significant that spring wheat be planted as early in the season as possible in regions where mosaic has spread.

As far as winter wheat crops are concerned, the incidence of disease can be reduced by observing the following conditions.

1. Seeding on dates fixed by agricultural regulations. The earlier seeding is done, the heavier the infection.

2. Normal rate of seeding. Thinned crops are always attacked more severely.

3. Shallow plowing of stubble of spring crops as early as possible immediately after harvest; also early fall plowing particularly on fields adjacent to winter crops. Fall plowing must be carried out before the appearance of sprouts of winter crops. Under these conditions a considerable number of carriers perish.

If the measures indicated are applied carefully, the development of mosaic epiphytotics can be cut off to a considerable degree.

In selection nurseries it is expedient to treat the young crop with DDT dust.

In the course of several years lemon and mandarine infection was observed on some citrus farms; manifestation of the disease was noted in the peeling of bark and in a heavy drop in the productivity of trees. The cause of the disease was unknown. In investigations conducted at the laboratory of virus diseases of plants of the Moscow station of plant protection (K.S. Sukhov and V.I. Kozlova) it was identified as psorosis - a virus disease spread in some other country. The disease is unique in that the grave symptoms appear after a very long incubation period lasting from 6 to 10 years and longer. Yet the tissues of the affected trees become infected early. The use of grafting material from trees concealing the virus leads to the spreading of infection. A threat arises that at the age of 10-12, i.e. at the time when the young plantation is in a period of high productivity, [Begin p. 54] part of the trees may suddenly develop disease and reduce or discontinue fruition in a short time.

Inasmuch as the only method of spreading disease under prevailing conditions is budding, the selection of healthy mother trees serves as the most important measure to prevent infection.

It has, however, been pointed out already that diagnosis by symptoms on the bark cannot produce results, since peeling develops late. We were confronted by the task of working out a method of early diagnosis of psorosis under conditions prevalent here.

It is known from foreign literature that psorosis infection in citrus trees is conducive to a rather early emergence of mosaic on newly developed leaves. This symptom is reliable, but it is ephemeral in the sense that mosaic is manifest for a very short time and then disappears.

As a result of investigations conducted by V.I. Kozlova, an applicable method was developed for mosaic diagnosis under our circumstances.

A special feature of mosaic in instances of psorosis is its transience. Mosaic is more pronounced during the spring period of leaf formation. It is not noticed on the youngest leaflets, but is more pronounced on the next formation of young leaves. Mosaic disappears in a few days, in proportion to the maturing of leaves. At the end of spring growth, it can no longer be found. Manifestation of mosaic is not observed on all the increment of new vegetation; it is found more frequently only on a small portion of the increment, sometimes only on single plants.

In the presence of psorosis, the mosaic pattern is very characteristic and cannot be confused with general chlorosis of a non-infectious nature, which at times is found on citrus plants. Mosaic appears in the form of bright little bands and is likely to be accompanied by a lighter coloring of the veins of lower formations. The bright bands are scattered over the leaf, or they form a regular pattern in the shape of a zigzag-margin of the main leaf vein reminiscent of the contour of an oak leaf. In this case, the tissues within the margin have a normal color, while a mosaic coloring is observed on the outside (fig. 2). Frequently circular or semi-circular spots of the same coloring as the bands or zigzag-shaped lines are found though-out the mosaic pattern. The mosaic pattern is very delicate and barely noticeable in reflected light if the leaf structure is sturdy. The mosaic is quite visible if the leaf is examined in penetrating, diffused light. Its examination is difficult in direct sunlight.

Careful inspection of trees from which grafting material is taken presents an opportunity to reject sick specimens and thus to prevent the spreading of infection. Diagnosis, naturally, takes into consideration also symptoms which appear on the bark. Since citrus bark sometimes bears injuries in the form of so-called "burns" caused by sharp changes in temperature between day and night in winter or in early spring, a distinction must be made also between these injuries and psorosis peeling.

In cases of psorosis, the bark begins to change with the appearance of small bulges or pustules which sometimes are scattered over the trunk and sometimes combined into groups. In the area of pustules the bark begins to split and its exterior layer begins to separate. As thedisease progresses, the splitting is likely to stretch over the entire trunk in a continuous hand and to transfer onto separate branches of the first and lowest formation. The infection increases gradually. Bark proceeds to come off in the form of scales or shreds. The bark beneath the peeling layers acqires a brown or yellow color. In time, infection penetrates ever deeper and finally reaches the wood which darkens and sometimes takes on a dark-brown coloring.

[Begin p. 55] "Scalds" present a different picture of symptoms: brown strips form on the bark, then split and come off the wood. In the course of a summer the lesion is margined by excrescence resulting from the activity of cambium, and frequently the wound heals. Open wounds margined by excrescence are likely to form in cases of multiple "scalds". Such a structure of the "scalds" distinguishes them easily from psorosis infections.

Considering the gravity of psorosis as a fector in reducing the productivity of citrus crops, it is necessary to inspect most carefully and continually the farms situated in regions where the disease has spread. Uprooting of diseased but still fruitbearing trees is inexpedient and unnecessary since there are no natural means of spreading the disease under conditions prevalent here. Careful marking of sick trees becomes more important, for it fully eliminates the possibility of utilizing infected buds for grafting. Essential measures in organizing such inspection is the inclusion of psorosis in the group of items under observation of the quarantine service, and adequate knowledge of the diagnosis of the disease by citrus growing agronomists.

Virus diseases cause great losses of vegetable crops. In the still recent past the epiphytology of "stolbur" of tomatoes and other Solanaceae appeared to be an enigma. The distribution of this disease is in the southern regions of the country where it occasions serious infection. Heavy outbreaks are not infrequent and then most plants on tomato plantings prove to be infected. The extent of damage caused by the disease is determined by a sharp increase of sterility in flowers which turn green, as well as by the lignification of the pulp of fruit which renders it inedible.

The rapid growth in "stolbur" epiphytotics and the mass infections seemed to contradict the fact that the disease is entirely non-infectious under ordinary conditions. Juice from sick plants causes no infection when it is rubbed into leaves and stems of healthy tomato plants. Nonetheless, the infectiousness of the disease was proved in 1931 when its transmission to healthy plants was accomplished by means of grafting (Ryzhkov and Korachevskii, 1934). The only explanation for the epiphytotics of the disease is the hypothesis that it is transmitted by some suctorial insect. For this reason Korachevskii (1941) conducted tests with several varieties of aphids, cicada and other insects, but the carrier of "stolbur" was not found among them.

Since our basic task remained unsolved, various conjectures and hypotheses began to surround this question. The wide-spread opinion was that the pathogenic agent was not introduced into plant tissues from without, but formed within them endogenously as a result of physiological disturbances caused by unfavorable ecological conditions. This case was a repetition of instances that have arisen more than once in the history of medicine and phytopathology. It suffices to recall malaria - the very name of this disease indicates a purely ecological interpretation of its nature at a time when nothing yet was known about its causal agent or carrier. In this category belong also hydrophobia, yellow fever, and - in phytopathology - pupation of oats, dwarfing of rice and a series of other diseases.

Inasmuch as stolbur is characterized by a southern realm of distribution, the cause of this disease was sought in high temperatures of air and soil. An opinion to this effect has been expressed more than once (B.I. Serbinov, 1941; P.I. Dvornikov, 1941; A.I. Serebriakov, 1941). Some saw the cause of disease in water starvation of plants (Medish, 1938). These conclusions, not verified under strict experimental conditions, were refuted by other investigators (I.K. Korachevskii, 1941; O.N. Vertogradova, 1941). [Begin p. 56.] The contradictions found in all these hypotheses clearly indicated that the nature of the disease had not been revealed; as a result, practicing enterprises could not obtain sufficient funds for its control.

Investigations conducted for several years by the Laboratory of Genetics of Microorganisms and Variability of Viruses, Institut of Genetics, Akademy of Sciences USSR, revealed fully the epiphytotics of stolbur, and the method for its control proposed by the laboratory passed successfully industrial tests and was accepted for adoptation in industry.

Epiphytotics develop on the basis of the following principles. In southern regions infection nidi are concentrated in perennial weeds of which European bindweed [Convolvulus arvensis] and cress [Lepidium] are the most significant. These plants are attacked by stolbur en mass regardless as to whether or not susceptible cultivated plants are near-by. The great susceptibility of these weeds is determined by their being the principal subsistance plants of a carrier insect which proved to be the cicada, Hyalesthes obsoletus.

The larval phase in the life of this cicada proceeds on the rhizome of European bindweed and cress. If larvae develop on diseased plants, they become infected by the virus which remains within them for an extended time. In early June, after the formation of wings, the cicadas appear on the surface of the ground and continue to live there for some time in the places of breeding [vyplod]. Soon after, they migrate to the plantings of cultivated Solonáceae. The greatest mass migration occurs between June 20 and July 5. This period determines the spreading of the virus to plantings of tomatoes, pepper, eggplant, tobacco and potatoes.

After finishing migration, the cicadas lead a stationary mode of life within the limits of a given plantation where they hatch eggs in the soil near the root neck of European bindweed, cress and some other perennial weeds on the planting. While feeding on these plants, they cause their infection. Mature individuals begin to die off in July, and adult cicadas are found rarely in August. Larvae developed from the egg still in summer settle in the rhisome of weeds and there pass the winter.

Since the incubation period of "stolbur" lasts in tomato plants from 30 to 45 days, the manifestation of the disease occurs at the end of July and lasts until the middle of August.

Epiphytotics reach their maximum development in August.

The period of mass migration of the carrier is fairly short - two weeks altogether; this makes it possible to safeguard plantings effectively by application of DDT dust. This method was worked out jointly by the author and A.M. Vovk in the years of 1947-1949. The results were good, and in 1950 the method passed industrial tests organized by the USSR Ministry of Agriculture, and later was accepted for adoptation in a number of southern regions.

Four-time dusting carried out on June 20, 25, 30, and on July 5, with each dusting consuming 20 kg of dust (dusting was not unbroken, but was done over rows) reduced the percentage of infected plants by 3-4 times, as established on the "Krasnyi Tamanets" kolkhoz in 1950.

This method combined with superior agrotechnics produces good results. An important factor is also the wide-spread use of stem varieties distinguished by relative resistance to "stolbur." Weakening of plants under conditions of poor agrotechnics increases the losses inflicted by "stolbur."

Solution of the problem concerning mass wilt of pepper, eggplant and potatoes in southern regions was also new. It was demonstrated under rigid experimental conditions that this disease is also caused by the "stolbur" virus, although its symptoms (wilt) on the crops referred to are different from those on tomatoes (K.S. Sukhov and A.M. Vovk, 1949). [Begin p. 57]

Experiments have shown that an efficient method of safeguarding seed-potato plantings against stolbur is the one proposed by Academician T.D. Lysenko, whereby the planting is carried out in mid July or about the 10th of July. "Stolbur" is not found on such plantings, because the disease vector leads of stationary mode of life during this period and does not invade new areas. Yet, spring planting of consumer potatoes must be carried out as early as possible so as to give them enough time to accumulate a sufficient yield before "stolbur" wilt appears.

The work indicated was used in the People's Republic of Bulgaria where epiphytology of "stolbur" develops fundamentally along the same principles. "Stolbur" wilt of potatoes has been identified in Armenia (Khachatrian, 1950). According to Samundzhova's data (1949-1951), it has been established that transmission of "stolbur" under Gruzian conditions is due to the cicada Hyalesthes mlokosiewiczi, related to H. obsoletus.

Another harmful disease of tomatoes is mosaic; its infections are particularly severe under conditions of covered [greenhouse etc.] ground. Even in the usual course of the disease, in which the main symptoms are a mosaic coloring of leaves and some depression of growth, yield is reduced by 10-15%.

Under certain ecological conditions more serious infections, characterized by the dying off of tissue sections on stems and leaves, are likely to form on tomatoes with mosaic. In this phase it is called the streak disease, or striped mosaic, since the areas of dead tissues on the stem show elongated dark stripes.

The noxiousness of the streak disease is determined not only by a general deterioration of the condition of the plant, but also by the spoilage of fruit sets which develop necrotic spots and ulcerations.

Conditions conducive to retention of infection and to its spreading are the same as those for tobacco mosaic, since the causal agent of the disease in tomatoes and in tobacco is one and the same virus. Distinct from the tobacco disease, a small percentage of tomato mosaic is transmitted by seed. This creates a supplementary and more permanent source of infection on the plantings. M.I. Gol'din (1948) proposed disinfecting tomato seed with a 1% solution of postassium permanganate for 5 minutes with subsequent rinsing of the seed in water. Such disinfection reduces initial cases of infection, but does not eliminate them fully. Therefore A.M. Vovk's suggestion, that in covered ground farming only tomato seed gathered from healthy plants be used, must be considered as more expedient. At present there has arisen a need for establishing seed growing tomato nurseries with covered ground and with open ground where healthy plants, carefully inspected as to virus transmission, would be grown for seed. Testing of juice pressed from tomato leaves on the leaves of Nicotiana glutinosa helps to determine unmistakenly concealed virus vection and to sort out the plants. Inoculation of the jice into glutinosa leaves in which the virus is present causes easily perceptible necrotic spots to develop on them within three days. Maintenance of a certain number of glutinosa plants for this purpose presents no difficulties on greenhouse farms, and the additional work connected with the selection of healthy plants pays for itself in a very short time.

Nonetheless, the seeding of healthy seed for seedlings does not solve the whole problem. External sources of infection may continue to exist in greenhouses on different articles of equipment, such as shelving boards etc. Therefore, the prerequisite for growing healthy tomatoes in covered ground is the elimination of infection contacts which occur during the thinning of seedlings, during their transplanting into ground etc. [Begin p. 58] The current practice of sowing seedling tomatoes in peat-humus pots eliminates such contacts during the seedling period, which is very important since the first infections occur already during the thinning of seedlings. Tomatoes grown by this method are not subject to thinning and are transplanted into ground together with the pots. Transplantation can be accomplished without touching the stem or leaves with one's hands, which excludes the possibility of infection. After this, new contacts with plants take place during the removal of suckers. Infection occurs easily during this operation. It can be fully avoided by removing suckers with pincers and scissors, and not by hand. After removing suckers from 3-5 plants, the instruments are disinfected by instantaneous immersion of their working parts in a 10% solution of trisubstituted potassium or sodium phosphates, or in a 10% solution of tannin. Such disinfection does not take too much time and insures fully against the transmission of infection. The alkaline solution is kept in a shallow glass flask which the worker carries on a strap. The pincers must be disinfected the same as the scissors.

This simple method involving minor expenditures eliminates fully the possibility of spreading infection during the removal of suckers. Tomatoes can be tied up only with a cord that has not been in use previously. At the time fruit is being harvested, infection can be avoided by holding the cluster with pincers which are being disinfected from time to time, and by tearing the fruit off by hand.

We have cited all these details for the purpose of showing how simple methods practiced to eliminate infection can be when they are known. At the same time, it must be emphasized that in covered ground tomato agrotechnics, these methods have not been taken into consideration up to now. It is obvious that the time is ripe for the initiation of appropriate scientific and organizational measures bound to raise the level of covered ground farming as a whole and to create agrotechnics answering modern demands.

An interesting solution of a problem was obtained by developing means for the control of white mosaic of cucumbers. Cucumbers of covered ground are often attacked by green mosaic No12. The biology of the virus-agent of this mosaic has much in common with the biology of the virus of tobacco mosaic. The virus is strictly specific for the gourd family and plants of other families are not susceptible to it. Infection is spread by seed and is easily transmitted through contact. Green mosaic is distinguished by moderate noxiousness which decreases yields by 10-15%. On some farms, however, heavy epiphytotics of white mosaic flare up on cucumber plantings from time to time. In such a case the drop in yield reaches 70 and even 90%. Inspections of covered ground farms conducted by our follow worker, A.M. Vovk, have induced him to draw the conclusion that white mosaic develops as a result of directed variation of the virus of green mosaic under the influence of extremely high temperature.

Significant spreading of green mosaic was observed on cucumber plantings in greenhouses under the customary conditions, white mosaic, however, was not found. Heavy attacks by white mosaic were noted only in those greenhouses where temperature was maintained high, at times exceeding 35° C. To inquire into this situation, A.M. Vovk conducted special experiments at the Institute of Genetics, Academy of Sciences, USSR. Cucumber plants infected by the virus of green mosaic were placed in a glass-inclosed compartment where temperature was maintained at 37-40° C. Under these conditions, single white spots appeared on developed upper leaves in 7-10 days. Their number and dimensions grew gradually and in a short time white mosaic dominated the plants. The same result was obtained in a series of replications, in accordance with natural law. [Begin p. 59] Thus, the virus of green mosaic, under the influence of increased temperature, underwent directed modification into the virus of white mosiac. A special feature of the latter was its being adopted to new conditions of temperature and being able to displace easily the virus of green mosaic unadapted to these conditions.

Separate isolates of the virus of white mosaic infected cucumber plants growing in a greenhouse under ordinary conditions. White mosaic developed on the plants. The same result was obtained in the next transition [passazh]. Consequently, the new property of the virus became fixed by heredity. It must be pointed out that during two transitions the virus had multiplied by hundreds of thousands and, consequently, the retention of acquired characteristics in a series of such multiple generations testified the high degree of constancy of the new form. Yet, under ordinary conditions, the virus of white mosaic could survive only in an isolated state, in the absence of green mosaic. In mixed inoculation of cucumbers, i.e. with both viruses, the original form, as the one more adapted to ordinary temperature conditions, displaced the new form. In proportion to the growth of new leaves in a cucumber infected by both viruses, green mosaic was becoming more predominant on them while white mosaic disappeared completely as time went on.

The experiments described helped to establish fully and clearly the cause for the emergence of white mosaic. On the basis of this research definite recommendations can be made to covered ground farms for the prevention of epiphytotics of a very noxious disease.

Antagonism between viruses of green and white mosaics, their incompatibility within the organism of one and the same host plant indicates that they belong to different species. In the given case, as well as in a series of other cases, we witness the formation of species in viruses under control conditions.

We deem it important to emphasize that a study of the regularities of directed variation in phytopathogenic viruses is of great theoretical importance. Some aspects of this problem can be solved more easily on the simplest nucleoproteid viruses than on cellular organisms. A contributing factor in this respect is the rapid tempo of virus multiplication, their high plasticity and their capacity to maintain activity under deviating conditions. The relatively simple structure of viruses makes them a particularly convenient object for theoretical investigations concerning their variation and specific formation.

The theoretical significance of research on directed virus variation becomes the more important as the identification of viruses with so-called "free genes" persists in Morganist virological literature. Variability of viruses is being treated from the position of the occasional mutations theory. Many facts of virus variation are under dispute and the appearance of new forms is being explained by their separation from populations where they, so to say, had existed all along in an undisclosed state.

Work conducted at the Laboratory of Genetics of Microorganisms and Variability of Viruses, Institute of Genetics, Academy of Sciences, USSR, has disclosed a series of factors under the influence of which regular, directed virus variation develops. Cultivation of viruses in plants belonging to different species, or in plants of one species grown under changed ecological conditions furnished such factors. Directed changes in the form of the tobacco mosaic virus were obtained, for instance, as a result of cultivation of an infected host plant at increased temperatures. The reality of the process of directed virus variation was demonstrated irrefutably in those investigations, and the hypothesis of a separation of ready forms from populations was repudiated. The very fact that virus forms adapted to life in plant tissues with a sharply disturbed metabolism [Begin p. 60], characterized by degradation and decomposition of proteins obtained in these experiments, furnishes important material that will help to understand virus nature.

A study of the regularities of directed virus variation opens up wide perspectives for the study of the processes of species formation among them. Bacteria and viruses can and are already producing material most accessible to the investigation of this problem. A wide field for the investigation of directed virus variability, is presented by the problem of protective vaccination of plants. For the time being, this question remains unsolved, with only the first steps having been taken in this direction in our laboratory. The establishment of numerous facts of antagonism and incompatibility of related virus species within one and the same host plant offers a good basis for directed production of mildly virulent but harmless forms of viruses, which might serve as live vaccine safeguarding plants inoculated with it against severe infection caused on the part of related, strongly virulent viruses.

The development of this mehtod encounters great difficulties, but its perspective for certain agricultural crops is clear, and it deserves much attention.

Control of virus diseases of plants should be expanded in other directions also. Chemotherapy of virus diseases has remained until now a neglected department. Systematic work for the discovery of antibiotics which inactivate viruses is being done nowhere. The initial phase of such work must of necessity be included right now in the complex investigations by virologists and microbiologists.

But even in those spheres of agricultural virology where research has been conducted long ago, and where many achievements have been attained, the work must be strengthened. This, to begin with, concerns development of agricultural conditions that will increase the resistance of plants to virus diseases. Means of crop protection such as chemicals must be considered as strictly extraordinary measures required in acute cases. They must be replaced with special means of agrotechnics in which primary importance will always be attached to factors of plant nutrition, time and methods of seeding, structure of crop rotations, weed control, and prophylactic measures.

Efforts must be made to expand selection work for the development of varieties resistant to virus diseases. The results of selection work obtained in cotton and tobacco culture, where virus infection can literally by eliminated by high varietal resistance, indicate a clear prospect [of success].

Finally, it is very important to expand and intensify the theoretical work in the sphere of virology which will always be of great signigicance in practice.

REFERENCES

Agapova, I.V. 1953. Influence of grafting upon variability in the susceptibility of certain Solonaceae to virus. Tr. In-ta Genetiki AN SSSR, No.20.

Bryzgalova, V.A. 1945. Pupation of oats and measures for its control. Irkutsk.

Butsevich, L.A. 1952. Some properties of the virus of top chlorosis of makhorka. Tabak No.4.

Vager, R.M. 1953. Stolbur wilt of potatoes. Mikrobiolgoiia, 32, No.2

Verderevskii, D.D. 1941. Leaf curl - virus of green mosaic of cucumbers into virus of white mosaic under conditions of increased temperature. Tr. In-ta Genetiki AN SSSR, 21.

Vertogradova, O.N. 1941. Virus diseases of tomatoes in the Lower Volga area. Tr. Soveshch. po Virusn. Bolezniam Rastenii, M.

Gol'din, M. and Pariovskaia, A. 1948. Practicing control of tomato mosaic and streak disease. Dokl. VASKHNII, 12/33.

Grushevoi, S.E. and Popova, A.A. 1951. Control measures for top chlorosis of makhorka. Tabak, No.2.

Dvornikov, P.I. 1941. Problem of agrotechnical measures for the control of stolbur. Tr. Sovesshch. po Virusn. Boleznian Rastenii. M.

Zazhurilo, V.K. and Sitnikova, G.M. 1940a. Means for spreading of virus of winter wheat mosaic in nature. DAN SSSR, 29, No.5. 1940b. Mosaic of spring cereal crops in the Voronezh Region. DAN SSSR, 26, No.5.

Ivanovskii, D.I. 1892. Two diseases of tobacco. Sel'sk. Khoz. i Lesovodstvo, No.3. - 1902. Mosaic disease of tobacco. Varshava.

Kozlova, V.I. 1951. Peeling of citrus bark and measures preventing its spreading. Dokl. VASKHNIL, 7/36.

Korachevskii, I.K. 1941. Searching for control measures for stulbur in vegetable gardening. Tr. Soveshch. po Virusn Bolezniam Rastenii. M.

Lysenko, T.D. 1935. Theory of plant development and control of potato degeneration in the South. Iarovizatsiia, No.2. - 1940. Summer planting of potatoes. M.

Mauer, F.M. 1940. Prospects for selection of virus resistant varieties of Egyptian cotton in Azerbaidzhan. Tezisy Dokl. Soveshch. po Virusn Bolezniam pastenii, M.

Modish, M.N. 1938. Spreading of stolbur on tomatoes in relation to ecological conditions. Virusn. Bolezni Rastenii, Sb. 2, M.

Moskovets, S.N. 1951. Leaf curl of cotton, M.

Razviazkina, G.M. 1952. Tobacco thrips - carrier of top chlorosis of makhorka. Zoolog. Zh., 31, No. 1.

Ryzhkov, V.L. and Korachevskii, I.K. 1934. Virus diseases of tomatoes during experiments in artificial infection. Sb. Virusn. Boleznei Rastenii v Krymu i na Ukraine, Simferopol'.

Samundzhova, E.M. 1949. Some data on the study of the tomato stolbur carrier in Gruzia. Tr. In-ta Zashchity Rastenii AN Gruz. SSR, Vyp. 159. - 1951. To study of distinguishing characteristics of stolbur carrier in Gruzia. Soobshch. AN Gruz. SSR, 12, No.6/361.

Serbinov, B.I. 1941. Development of control measures against tomato stolbur in the Moldavian SSR, Tr. Soveshch. po Virusn. Bolezniam Rastenii, M.

Serebriakov, A.I. 1941. Tomato stolbur in the zones of canning factories in Krasnodar Territory. Tr. Soveshch. po Virusn. Bolezniam Rastenii, M.

Sukhov, K.S. and Vovk, A.M. 1940. Pupation of cultivated cereals and its spread in nature. M.- 1949. Stolbur of Solanaceae. M.

Sukhov, K.S. Characteristics of two cereal viruses. Mikrobiologiia, II, No.5 - 1952. Virus of top chlorosis of makhorka. DAN SSSR, 85, No.6.

Sukhov, K.S. and Kozlova, V.I. 1951. Methodical instructions in inspection of citrus crops as to psorosis infection (peeling of bark).

Sukhov, K.S., Vovk, A.M. and Mushnikova, K.S. 1952. Industrial tests of DDT dust in the control of tomato stolbur. Dokl. VASKHNIL, No.8.

Sukhov, K.S. and Razviazkina, G.M. 1953. Top chlorosis of makhorka, its causal agent and vector. Tr. In-ta Genetiki AN SSSR, 20.

Ternovskii, M.F. 1950. Immune tobacco varieties. Selekts. i Semenovodstvo, No.10. - 1951. Resistance variation in tobacco mosaic as a result of vegetative hybridization. DAN SSSR, 29, No.3.

Fedorenko, M.IA. 1952. 85.4 centners of makhorka per hectare. Poltava.

Khachatrian, G.A. 1950. Stolbur potato wilt in Armenia and its transmission in grafting. Izvest. AN Arm. SSR, 3, No.12.

Khudina, I.P. 1936. Virus diseases of tobacco in the USSR. Krasnodar. - 1941. Virus diseases of tobacco and Makhorka in the USSR and their control. Tr. Soveshch. po Virusn. Bolezniam Rastenii, M.

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Content and Conclusion
By R. Adolman

Brezhnev, D. D. and Aizenshtat, IA. S.

Novoe v selektsii rastenii.

[Something new in plant breeding].

Gosudarstvennoe Izdatel'stvo
Sel'skokhoziaistvennoi Literatury
Moskva 1954 Leningrad
144p. 463.62 B75

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SOMETHING NEW IN PLANT BREEDING

CONTENTS

CONCLUSION

Problems analyzed in the present work deal with the control of vitality and heredity in annual herbaceous plants and in their hybrids.

The influence of cultivation conditions upon the formation of various characteristics has been demonstrated on a wide assortment of material. A special feature of these investigations was the comparative study of plant behavior in different agro-climatic zones. The large varietal and specific stock utilized in the work speaks very convincingly of the influence of conditions exerted upon the formation of a whole series of agriculturally important characteristics. Morphological characteristics as well as biological (and biochemical) properties of plants change under the influence of cultivation factors. Dynamics of growth and the inception of generative organs proceed differently; time of flowering, ripening of fruit and their chemical composition vary. The variations which crop up may be so considerable as to exceed the limits inherent in the indicators of a species of variety.

A variety changes its nature when transferred to new conditions of cultivation. Hence the clarification of the reaction of different varieties to the influence of external environment is of great importance in the work of selection. It is well known that varieties developed and regionalized for a certain locality can be cultivated successfully in other regions and other climatic zones. In clarifying the possibilities of regionalizing a variety, it seems to us that its testing by the method adopted by the state variety testing network only is insufficient. It is important to show to what extent a variety is capable of assimilating factors of cultivation and of responding to them with changes of separate properties and characteristics. Only the knowledge of the nature of behavior characteristics under appropriate conditions makes their control possible. The work cites data which demonstrate the means of modifying the characteristics of the length of the vegetative period, the chemical properties of fruit, their form, productivity etc. Special features meriting attention are those involved in the formation of characteristics under conditions of irrigation, this must be taken into account when new varieties are being developed and those existing in irrigated regions are being utilized.

All methods developed for control of the formation of characteristics assume importance in the event they can be fixed in the progeny. Quite logically, the following chapter of the work is devoted to the problem of inheritance of acquired variations. Thus far, Michurinist biological science has at its disposal comparatively little factual material corraborating inheritance of characteristics under the influence of environmental conditions, [Begin p. 137] and the accumulation of new facts in this sphere is of great importance. The book cites data which demonstrate that acquired variations become a requirement of the organism and are preserved in progeny cultivated under new conditions. The capacity of plant organisms to fix acquired variations is extremely significant in selection. When the factors facilitating the formation of a definite characteristic and its fixation in progeny will be known, then the breeder will be able to control its development. The book cites data indicating the possibility of fixing modified properties and characteristics of tomato plants in the progeny: length of the vegetative period, form of fruits, their chemical composition, and a series of others. The basic method used to modify properties is rearing plants under conditions deviating from the customary (intrinsic) requirements of a crop. A tomato crop that thrives in a warm climate changes its nature (heredity) and acquires the property of enduring low temperatures, if its subsequent seed generations are reared under conditions of low temperatures. Directed selection aimed at acquiring cold-resistant properties is particularly important when a crop is being moved to more northerly regions. Increased cold-resistance in tomatoes is important also for the central belt, the Baltic Republics, White Russia. The book contains methods for increasing cold-resistance of this particular crop. Results obtained by one of the authors (D. D. Brezhnev) are indicative of the effectiveness of the methods suggested. With the cooperation of P. P. Gusev, a science fellow of the Polar Station of VIR (All-Union Institute of Plant Industry), he succeeded in resolving the problem of growing tomatoes in open ground [outdoors] under trans-polar conditions. The book reveals conditions for the inheritance of morphological, biological, physiological and other properties in tomato plants. As in the case of influence exerted by cultivation conditions upon the formation of characteristics, there is data on the hereditary differences in plants cultivated in arid areas and in those under irrigation.

A separate section of the book (chapter) is devoted to factors increasing the vitality of hybrid organisms. New methods of intra-varietal crossing are also included. A distinctive characteristic of these methods is the growing of parent plants under different conditions. The additional differentiation of sex gametes thus created leads to a considerable increase in the vitality of progeny, its productivity and early ripening. There are indications that the opinion established in selection science, that utmost heterosis can be obtained by selecting parent pairs which differ in morphological characteristics, is not always correct. Obviously, the biological differences in the plants to be crossed, created by dissimilar conditions of cultivation, perform an important role. Works on crossing plants reared under conditions as sharply diverse as hothouse and open air culture, and a series of others, are of interest. [Begin p. 138] Methods connected with regulating the state of the plant and its sexual elements in terms of age are completely original. At different stages of its development, the plant and its reproductive organs produce a progeny with dissimilar vitality. The most productive seed produce plants in the period when their development proceeds most vigorously, at a so called "age of puberty". The same applies to the state of the flower. Considerable increase in the yield of hybrid progeny is obtained by pollination coinciding with the greatest vitality in the state of the plant (the flower). The method of preliminary grafting is also effective. In a series of cases it is instrumental in nearly doubling the yield of fruit as compared with ordinary hybridization (crossing). Finally, it demonstrates the possibility of using the method of added alien pollination for the purpose of increasing the vitality of hybrid progeny.

A number of the following chapters are devoted to control of heredity in crossing. The methods suggested are founded on interference (control) in the sexual process and on nurturing the embryo at the earliest possible stages of development.

The method of preliminary mentor which combines sexual and vegetative hybridization is aimed at influencing the maternal organism prior to crossing, and the developing hybrid embryo after fertilization has taken place. Preliminary grafting makes it possible to obtain hybrids with paternal heredity even in cases in which the paternal plants are represented by more "persistently" recessive forms, as, for instance, a leaf of the potato type and the yellow color of tomatoes. Particulars of preliminary grafting are explained as applied to tomatoes under southern and northern conditions. To obtain variations in more conservative characteristics in the South, a one-time grafting is sufficient. In the North in such cases it is necessary to resort to grafting F_1 plants on the original parent forms. According to the characteristics of the fruit, in the work of selection a one-time grafting is sufficient even in the North. The role of age variation in annual plants in the inheritance of characteristics is also demonstrated. In different phases of age, plants transmit their properties to the hybrid generation with different vigor. The maternal type of heredity which responds to a more vigorous plant development is transmitted more fully by pollination of clusters of the central formations. Characteristics of maternal plants are transmitted less vigorously in pollinations of the first flowering clusters and blossoms of aging plants. As applied to tomatoes, the cultural practices which assume importance are: Greenhouse and open air cultivation. In the South this period (transplantation in the open) is less severe than under northern conditions. Hence, somewhat different results are observed in the pollination of the first flowering clusters which usually form while still in the greenhouse. In the case of pea culture, age variations appear in a "purer form". In crossing peas [Begin p. 139] (this, obviously, applies to a certain extent to all annual crops) one must keep in mind the early ripening of the plants - "age within itself". In cases in which both parents ripen equally early, age differences of the mother plant suffice to obtain certain variations; if, however, development (early-ripening) varies, one should resort to additional age differentiation by planting the parents at different dates.

A very effective method is the regulation of the age state of sexual elements (ovicells, pollen). Pollination of a flower (ovicell when its flowering period is ending strengthens considerably paternal heredity in the progeny. Here, a change of domination can take place, even cases in which the parent plants are represented by clearly recessive forms. It must be remembered that the age of a flower has meanings other than the calendar idea, and is characterized by a physiological condition due to many factors, chiefly weather conditions.

The application of "highly mature" ["starovozrastnoi"] pollen makes it possible to strengthen the maternal type of heredity and may prove to be an efficient method in selection, particularly in cases in which it is desirable to preserve the cultivated type of plant in crossing with wild forms.

Apart from utilizing pollen of various ages for the purpose of controlling heredity, knowledge of the characteristics of progeny behavior during its application has still another significance in the work of selection. It is known that it often becomes necessary to store pollen. It is enough to point out such a necessity in crossing forms with non-coincident dates of blossoming, forms geographically remote, and varieties grown in different localities (due to transfer of pollen) etc. The data which we have cited can serve as certain orientation in all these cases. Up to now, the problem under consideration has found no clarification whatever in literature. The book demonstrates the possibility of controlling the force of hereditary transmission by regulating the amount of pollen dropped on the flower stigma, and by multiplicity of pollination. Reduction in the amount of pollen applied (limited pollination) strengthens the transmission of maternal properties. The opinion established in literature that offspring of limited pollination must possess certain depressiveness is not justified in cases of intervarietal crossings. Two contrasting phenomena are encountered in fertilization due to a limited amount of pollen: weakened activity of the sex process, and better conditions of development (nutrition) of the hybrid embryo as a result of the small amount of seed formed. The latter circumstance may lead to a progeny possessed of high vitality.

Multiple pollinations strengthen transmission of paternal properties to hybrid progeny. Investigations of this sort were prompted by the hypothesis [Begin p. 140] that pollen is capable of germinating and of reciprocal action with the vegetative parts of the ovary and developing embryo in the course of extended time (at least 4-5 days) after fertilization has occurred. The high percentage of sets in instances of multiple pollinations (up to 100% of crossing success) and the efficiency of the method make it acceptable for selection work. A separate chapter is devoted to the role of supplementary alien pollination during hybridization. The breeder quite frequently encounters phenomena of insufficient pollination, or has to deal with pollen that is inefficient, partly sterile etc. In all such cases the normal course of fertilization is being disturbed and the character of progeny behavior changes. We have explained in our work the feasibility of compensating for the quantitative and qualitative deficiency of pollen by alien pre-pollination. Application of pollen of distant species (which takes no direct part in fertilization) increases the percentage of sets, and, in many respects, restores the usual (control) picture of hereditary characteristics. Added alien pollination with highly mature pollen takes on particular significance. Data cited in the book show that even pollen which has practically lost its capacity to fertilize, restores it to a considerable degree by added alien pollination.

The last chapter is devoted to the problem of ecologo-geographical influence upon the formation of characteristics in hybrid plants. Investigations conducted up to now on a small scale explain definite regularities of the development of characteristics in hybrids reared at certain ecologo-geographical points. The availability of a wide network of state selection stations and other experimental institutions located in quite different agroclimatic zones offers an opportunity to develop this, substantially new, trend in selection work. This still is the tomorrow of Soviet selection, but we deem it timely to call it to the attention of wide circles of breeders.

On the whole, the methods which we propose are technically simple and entirely accessible to any experimental institution.

Trans. A. 533
Conclusions only
By R. Adelman

Avdonin, N. S. and Khudiakova, Iu. A.

O sposobakh effektivnogo ispol'zovaniia azotogena

[Methods for effective utilization of azotogen].

Voprosy Povysheniia Plodorodiia Pochv
Nechernozemnoi Polocy
Izdatel'stvo Moskovskogo Universiteta, 1954
p.83-103 56.6 M85

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CONCLUSIONS

1. Azotogen applied on saline sod-podzolized soils by methods now available is ineffective. This can be explained by the fact that azotobacter introduced in sod-podzolized soil finds itself in an environment deficient of phosphorus and organic substances, with an excess of motile forms of aluminum, in the presence of rivals of azotobacter adapted to conditions of podzolized soils. The destruction of azotobacter in saline podzolized soils is aided by its introduction in pulverized form after having been sensitized through maintenance on artificial media.

2. To apply azotogen successfully, it is necessary to create for it favorable living conditions in soil and to change the methods of its introduction in soil, along with the development of stable azotobacter races.

3. Special "azotobacter granules" representing nidi with conditions favorable to azotobacter have been suggested. These granules are prepared from neutralized soil, humus, and neutralized superphosphate. The mixture of substances indicated is infected with pure azotobacter cultures, converted into granules, and introduced into the soil.

4. Whenever azotogen was introduced into specific "granules", azotobacter lived, multiplied and fixed atmospheric nitrogen upon finding these "granules" in acid sod-podzolized soil (pH 4.6) in the course of two vegetative periods, while it perished if introduced by the old method. Azotobacter "granules" introduced under potatoes increased their yield substantially.

5. A property of "granules" important to azotobacter is their buffer capacity, i.e. the capacity to keep environmental reaction on a certain level. This was achieved by including neutralized soil in the "granules" and by creating a lime coating about them. Thus the environmental reaction in the "granules" upon finding them in acid soil (pH 4.6) kept up for two vegetative periods on a level of pH 6.2--6.8.

6. Preliminary propagation of azotobacter on cultivated soil with a mildly acid or neutral reaction of environment increases the resistance of azotobacter to subsequent unfavorable conditions of subsistence.

7. Better development of azotobacter was observed during the first vegetative period when superphosphate content in the granules was 0.5%, and during the second vegetative period when superphosphate was maintained at 1%.

8. An addition of 5% of straw to the granule composition stimulated the development of azotobacter during the first vegetative period, but depressed it in the course of the second vegetative period.

Trans. A. 534
Cônclusions only
R. Adelman

Kalinkevich, A. F.

Formy azotnykh udobrenii pri
vnekornevom pitanii rastenii

[Forms of nitrogenous fertilizers
in external feeding of plants].

Zemledelia. 2(6):45-49
June, 1954 20 Z44

(In Russiam)

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CONCLUSIONS

Experiments in the use of various forms of nitrogen fertilizers as nutrition for maize and buckwheat have shown that urea, an organic form of nitrogen, is the best for external nutrition, and ammonium sulfate the poorest.

The advantage of urea over other forms of fertilizers lies in its considerable content of nitrogen which facilitates its introduction in small concentrations in fairly large doses through the leaves. Nitrogen introduced in the form of a urea solution converts more readily to albumin substances in the leaves. A 0.5% urea concentration produced no external changes in the leaves, while ammonium sulfate caused decomposition of the green part of chlorophyll and thus decreased their photosynthesis.

Such diverse action of mineral fertilizers (ammonium sulfate and ammonium nitrate) and organic fertilizers (urea) in external nutrition is due to the characteristics of foliar nutrition. In ordinary root nutrition, nitrogenous mineral fertilizers undergo synthesis into primary organic compounds already in the roots and, as a rule, enter the leaves in the form of organic compounds. In ordinary root nutrition, mineral nitrogenous compounds enter the leaves only in exceptional cases. This is observed in increased nutrition of plants with nitrogen when a part of mineral nitrogen reaches the leaves, and also in cases of protracted weakened photsynthesis and carbohydrate deficiency in plants.

Urea, upon landing on the tissue surface of a leaf covered with fatty substances, disolves in these substances and thus penetrates inside the tissue more rapidly and, being an organic substance, enters into reciprocal action with the plant tissue more readily than mineral substances (Gunar, I. I., 1952). It excels all available nitrogen mineral fertilizers in external feeding.

All this, plus the experimental application of herbicides and physiologically active substances, demonstrates that organic, soluble forms of nutrive substances, obviously, have advantages over mineral fertilizers in external nutrition.

Trans. A. 535
Conclusions only
By: R. Adelman

Borisova, N. I. and Zagainova, O. A.

Isol'zovanie izotopa P^{32} dlia otsenki postupleniia v rasteniia fosfatov iz pochvy i iz udobrenii pri posloinom i ravnomernom raspredelenii

[Utilization of isotope P^{32} in evaluating intake of phosphates by plants from the soil and from fertilizers distributed in localized layers and spread evenly [throughout].

Izvēstiiā Akademii Nāuk SSSR, no. 6, pp.111-116
Nov./Dec. 1953 (Ser. Biol.) 511 Sa2B

(In Russian)

CONCLUSIONS

1. Localized introduction of fertilizers into soil layers leads to more intensive utilization of fertilizers in the first period of plant development than does their even distribution.

2. According to the difference between phosphate intake in unfertilized and in fertilized experimental varients, determination of plant intake of phosphates from fertilizers introduced in the soil gives an impression of a minimal use of fertilizer phosphates in localized application.

3. In localized application of fertilizers, the consumption of soil phosphates during the first period of plant growth is less than in an even distribution of fertilizers.

4. In an experiment conducted on podzolized clayey soil with localized introduction of phosphates, utilization of fertilizer phosphates was relatively higher than that of soil phosphates, as per comparative experiments conducted on chernozem and sierozem soils.

5. The advantage of introducing fertilizer in the soil layer persists up to the time of harvest, as regards utilization of phosphates from fertilizers, but it is considerably less than in the first period of plant growth.

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6. In the second period of plant growth consumption of soil phosphates was more intensive than in the first period of their growth, when fertilizers were localized.

7. Aided by the method of tagged atoms, it was possible to obtain data allowing the hypothesis that the fundamental advantage of localized introduction of fertilizers (into a layer of soil) lies in the increased utilization of fertilizer phosphates by plants in the first period of their development.

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AGRONOMIC ORES

Artificial fertilizers have been utilized extensively in agriculture for many years. If used skilfully, taking into account the characteristics of the soil and the crop to be grown, they increase the yield by one and a half to two times, and frequently by even more. Their application is economical. The cost of the fertilizers, compared with the increase in yield which they produce, is not great. Thus, fertilizers are a powerful medium in raising the productive capacity of farm labor.

Various agronomic ores are used in the preparation of artificial fertilizers. The most significant among them are the potassium and phosphate ores, and also carbonate rock (limestone and dolomites). Gypsum and various minor elements are used in smaller amounts - to begin with, boron, copper, cobalt, manganese, iodine, molybdenum, uranium, vanadium and zinc.

The most prominent of the phosphate ores are apatite, phosphorite and vivianite.

Apatite ores are composed of fluorapatite mineral and different admixtures, principally nepheline and pyroxene. They constitute the Khibinsk apatite deposits on the Kol'sk peninsula. These deposits formed during the solidification of alkaline magma, apparently in the Devonian period, about 350 million years ago. The concentrate of these ores obtained by their granulation and enrichment consists almost entirely of fluorapatite and has proved itself an excellent product for chemical processing into soluble phosphate fertilizers, chiefly superphosphate.

The large apatite crystals found in mica veins in the vicinity of the city of Sliudianka on the southern shore of the Baikal lake have been know for over a hundred years and have been described in literature more than once. The quantity of these crystals, however, is not large. In recent years, Soviet geologists have found an accumulation of fine apatite grain the deposits of which are significant. The apatite in these deposits is accompanied by a large amount of admixtures and, therefore, it has not as yet been adapted to practical use. These deposits require further geological research for the purpose of finding ores of a higher grade, and a technological investigation aimed at defining a more efficient method for their processing.

Phosphorites have a fairly complex mineral composition. Their phosphate substances occur in the form of three widely distributed minerals - fluorapatite, francolite and kurskite. The content of P_2O_5 is the main qualitative indicator of raw phosphorus. Fluorapatite contains 42.23% of P_2O_5, francolite - 37.14%, and kurskite - 34.52%. [Begin p.31]

The minerological nature of francolite and kurskite has thus far only been studied superficially. There is no unanimous opinion even on as important a problem as the state of carbon and phosphate. Some insist that all phosphorites have been formed by fluorapatite and that kurskite is non-existent among them; others demonstrate the existence of these two minerals on the premise that their properties differ essentially from fluorapatite. The verdict of this hypothetical dispute is of substantial practical importance. If the veracity of the supporters of the first point of view will be established, then there will be hope for increasing artificially the P_2O_5 content in phosphorites up to 40-42%; if, however, the opposite opinion will triumph, then the attempts to raise the quality of francolite phosphorites above 37% of P_2O_5, and of kurskites - above 34.5% of P_2O_5 will be futile.

Minerologists must pursue the study of the minerological nature of the phosphate substances of phosphorites in earnest.

The two known most important types among phosphorites are the seam [plastovyi] and the nodular [zhelvakovyi] types. With such distinctions in form are connected distinctions of a mineralogical nature - seam phosphorites are deposited by francolite and partly by fluorapatite, and nodular by kurskite. Kurskite phosphorites are assimilated by plants more readily than francolites and fluorapatite: hence they are being utilized as phosphorite fertilizers without chemical processing. As separate entities the podol'sk phosphorite nodules stand out. They are deposited principally by fluorapatite and in part by carbonapatite.

Seam and nodular phosphorites had formed in shallow areas of ancient seas as biochemical precipitates and they occur among sea deposits.

The P_2O_5 content in seam phosphorites usually is equals to 25-30%, and in nodular, to 15-20 and infrequently to 25%. The magnitudes of seams in the first reach 10-15 m, and in the second 1-2 meters. Consequently, seam phosphorites have a substantial advantage over the nodular type with respect to a higher P_2O_5 content as well as the great magnitudes of the seams.

The seam type includes the Khoper, Seleuksk and Kara Tau phosphorites. The latter are of great industrial importance: they are being shipped to the superphosphate factories in Central Asia.

The Kara Tau deposits are distinguished by a high content of dolomite, which hinders the production of granular superphosphate and complicates the technological process phosphorite treatment.

Deposits of nodular phosphorites are widely distributed over the Russian plains and occur in the Urals, the Caucasus, in Central Asia and in Siberia. By the character of admixtures, quartz-sand and glauconite sand phosphorites stand out.

Deposits of quartz-sand phosphorites are known chiefly on the northern outskirts of the Dnepro-Donets depression (Briansk and Kursk Regions), and also in the Aktiubinsk Region. These are not high-grade phosphorites: their P_2O_5 content is equivalent to 15-19%. Their reserves, however, are very considerable and thanks to their occurrence at the surface, they can be extracted by open-cut mining.

Quartz-sand phosphorites used as phosphorite fertilizer were until recently of local importance. Modern methods of these phosphorites by flotation and producing a concentrate containing up to 25-27% of P_2O_5 have increased to a large extent the possibilities of their application.

Glauconite sandy phosphorites are distributed principally in the Moscow and Riazansk Regions, in the Chuvash Autonomous SSR, and in the vicinity of the upper Kama [river]. [Begin p.32] These phosphorites contain 20-25% of P_2O_5 and are easily crushed. As a result of their high content of ferric and aluminium oxides, they are not well suited for chemical treatment, and similar to quartz-sand phosphorites, are being utilized principally as phosphorite fertilizers. Their deposits are also considerable and are available for open-cut mining.

Until recent times, only phosphorite ores containing no less than 10-12% of P_2O_5 were considered economically valuable. For this reason no attention was paid, for instance, to obolus [obolovye] phosphorites long known in Estonia and the Leningrad Region (5-8 and accazionally up to 15% P_2O_5). Investigations have shown that these ores were composed of phosphate shells of the simplest Brachiopoda of the marine animals of obolus [obolius] and lingula, and an admixture of a large quantity of quartz sand grains. It was found that by crushing obolus phosphorite, it is possible to produce phosphate and quartz grain with almost no adhesions. Further flotation of this material permits the production of a high-grade product with a P_2O_5 content over 30%. Thus it became possible to expand considerably the possibilities for utilizing obolus phosphorite.

In Siberia, until recent times, deposits of phosphate ore were unknown. Formations of apatites and phosphorites found here in the last few years a re as yet scarcely adequate.

Vivianite is an aqueous phosphate of ferrous oxide. Its deposits occur in lowland peat moss. They are found in large quantities in the swamps of White Russia where vivianite is used as a fertilizer together with peat. Usually vivianite deposits are not large, but thanks to their distribution over a large territory, their occurance at the very surface, and the simple manner of extraction, they are being exploited successfully by kolkhozes.

Of great economic importance are potassium fertilizers for the production of which the deposits of chlorous and sulfate salts of potassium or of potassium with sodium and magnesium are utilized. These salts had precipitated from the salt-water in lagoons of early geological periods under arid and hot climatic conditions.

The USSR is mining two potassium formations - the Solikamsk and cis-Carpatian. The first had formed in the Permian period; the second, in the tertiary. Lately now, very promising deposits of potassium salts which had formed in the Devonian period were discovered. Potassium deposits are know also in the Ural-Embenskii Region and in the South of Central Asia.

All of these deposits have enough reserves to supply the country's demands for potassium fertilizers. The problem simmers down mainly to the pre-exploration of the old, and exploration of new localities for laying mines for the purpose of more efficient exploitation of all salt deposits.

Liming of acid soils is accomplished with various carbonic mountain rock deposited by calcium or dolomite - limestone, dolomitic limestone, dolomites, marble, chalk, marl and lime tuffs.

The exploitation of deposits of fresh-water lime tuff and swamp lime, or lake chulk, is more simple. Their formations usually are not large, but they are very numerous. Thanks to their friability these rocks need not always be crushed and, therefore, can be delivered directly to the field. They usually occur at the very surface which makes their exploitation much easier.

The USSR is known to have a large quantity of deposits of carbonic rock. Many of them have been diluted in detail and are being processed for various purposes. In so doing, frequently a considerable amount of the waste [Begin p.33] of "poor cross-section" [malogabar-tnyi] gravel which can be utilized successfully for liming of soils is obtained.

In conjunction with carbonic rock, good results a re produced on acid soils by manganese. The waste of manganese concentration factories serves as manganese fertilizer; low-grade manganese ore is used for the same purpose (in the Caucasus, the Urals and a number of localities in Siberia).

Gypsum is being used successfully for the improvement of alkaline soils in arid regions. Considerable deposits of gypsum are found in the Ural-Embensk Region, in Central Asia - precisely in the places where alkaline soils cover large areas.

Recently the application of magnesia fertilizers was begun; they proved to be particularly effective on sandy loam and podzolic soils. Dolomites and dolomitic limestone are the principle sources of magnesium. Deposits of these rocks are distributed extensively in USSR territory, and in many places they are diluted in detail and are easily available for extraction.

Magnesia silicate - dunite, pyroxenite and serpentinite can serve as supplementary sources of magnesium. Although, as regards assimilation of magnesium, they do not comes up to such readily soluble forms of magnesia fertilizers as sulfuric acid or potassium and magnesium chlorides [khloristye soli kaliia i magniia], or even to dolomites, their worth is enhanced by the frequent presence of cobalt and nickel within them. Huge deposits of magnesia silicates are known to be in the Urals, the Caucasus, in Central Asia and in many localities in Siberia. In some Ural mines large quantities of magnesia silicates are treated as waste products in the extraction of asbestos and other useful minerals.

The agrochemical effect of magnesia silicates has not as yet been sufficiently investigated; hence their geologic reserves are not considered as agronomic ore.

The work of many investigators has demonstrated the high effectiveness of boron fertilizers, especially on podzolic soils and forest sierozems. In the production of these fertilizers, the calcium and magnesium salts of boric acid - hydroboracite and ascharite are utilized. Their deposits are being mined on the Indersk formation in the Gurevsk Region. Other possible boron sources are the complex borosilicates - datolite and tourmaline. Boron occurs also in the waters of some lakes in Central Asia and in volcanic mud in the Crimea and the Caucasus. The boron content of these sources is low, and the expediency of extracting it from these waters and muds has not yet been investigated.

For the time being, the pure salts of corresponding metals are being utilized as microfertilizers. Considering, however, the vast cropping areas in the USSR, the demand for these salts is very great and their supply to agriculture is becoming a serious geological problem. It is essential to ascertain which natural minerals or rocks containing microelements could be utilized directly for fertilizing, and to estimate their deposits. In many cases it is possible to use industrial waste with microelement content.

Due to the absence of approved technical specifications for microelements as a raw material for fertilizers, geologists are unable to evaluate or estimate their deposits. The Ministries concerned must eliminate these inconsistencies.

At the conference concerning the geology of agronomic ores, held in May of this year at the Department of Geologic and Geographical Sciences of the Academy of Sciences USSR, the situation of the raw material base of the most important agronomic ores - phosphorites, apatites, potassium salts and raw boron - was examined, [Begin p.34] and means for its future expansion were noted. The conference resolved that it was necessary to continue the search for phosphorites in the Ukraine, the Caucasus, the Urals, in Siberia and the Far East. Recent new finds of phosphorites indicate the prospects of the search for agronomic ores in many regions of the country.

The conference noted that it was necessary to study the genesis of phosphorites and their minerology. The minerology of calcium phosphates has, by the way, been studied up to now only by separate geologists. The problem, however, proved very complex - the molecular structure of calcium phosphates which form phosphorites has not as yet been sufficiently ascertained. The hypothesis that carbon enters the phosphate molecule is particularly contraversial. The study of these problems must assume a systematic character.

Discussing the means for expanding the raw material base of the potassium industry, the delegates to the conference noted that geological petroleum organizations drilling wells fail to acquire complete selections of core [samples] from salt seams.

A potassium variety with the atomic weight of 40 possesses radio activity and occurs in potassium salt in the form of a constant admixture. Gamma-rays emitted by radioactive potassium penetrate easily the drive pipes of drill holes and, therefore, can be measured with the appropriate instruments. By measuring gamma-radiation in drill holes, it is possible to locate the potassium seam and to determine its magnitude and depth of occurrance. The conference resolved that it was necessary to accomplish such measurements in drill holes from which no samples had been taken during the time the drill stem was passing through the vein or seam of potassium salt.

Thus, to solve the problems confronting our country's agriculture, an extensive geological investigation of the deposits of various agronomic ores assumes an ever greater importance.

Trans. A. 537
By R. Adelman

Kedrov-Zikhman, O. K.

Khimizatsiia zemledeliia

[Chemicals applied to agriculture].

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CHEMICALS APPLIED TO AGRICULTURE

The September [1953] Plenum of the Central Committee, Communist Party of the Soviet Union, has charged our country's agriculture with the imposing task of raising the agricultural standard to a new, still higher level.

Successful implementation of this task will ensure a sharp rise in the productivity of agricultural crops, and will create an abundance of popular consumer goods in our country.

An increase in productivity is connected with a widespread adaptation of a series of agrotechnical measures of which the use of chemicals in agriculture ranks among the most important.

The application of chemicals to agriculture is accomplished fundamentally by the extensive use of fertilizers, and primarily mineral fertilizers manufactured by the chemical industry.

The production, and use of mineral fertilizers expanded in our country only after the Great October Socialist Revolution. In Czarist Russia manure was the main fertilizer used, but even that was applied in insufficient amounts and, in most cases, without observance of the most elementary agrotechnical requirements. Mineral fertilizers were imported from abroad in small quantities and used only on a few large manorial estates; to peasant farms, however, these fertilizers were unavailable.

After the revolution the situation was radically changed - production and use of mineral fertilizers began to develop at an unprecedented pace. As a result of investigations conducted under the guidance of outstanding Soviet scientists - the academicians N. S. Kurnakova, A, E. Forsman and Prof. P. I. Preobrazhenskii - rich deposits of phosphorus and potassium ore were discovered in the first years of Soviet authority. This permitted the organization and production of phosphorus and potassium fertilizers.

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In the Soviet Union, the basic phosphoric ores are found in the rich deposits of apatite on the Kol'sk peninsula and in the formations of phosphorite in different regions of the country including the large deposits discovered shortly before the Great Patriotic War in the Kara-Tau mountains in Central Asia.

The main sources of potassium fertilizers are the richest potassium salt deposits found at Solikamsk, and also in Kalusha and Stebniki (Western Ukraine).

Along with the production of phosphorus and potassium fertilizers developed also the production of nitrogen fertilizers based on the fixation of atmospheric nitrogen into ammonia. In selecting the technological process for this industry, the investigations of the eminent Soviet scientist, academician D. N. Prianishnikov played an important role. [Begin p.12] He demonstrated that not only nitrate [nitratnyi], as held prior to his works, but also ammonia nitrogen [ammiachnyi azet] can be utilized successfully in plant nutrition[1].

Organization of production and wide-spread use of mineral fertilizers in the USSR were closely connected with the realization of socialist industrialization of the country and collectivization of agriculture. The fertilizer industry was established in the USSR during the first five-year-plan. At the beginning of the second five-year-plan, our agriculture began to receive considerable amounts of mineral fertilizers and to use them under the basic technical crops - cotton, sugar beets, tea, citrus, flax, hemp. As a result, the yield of these crops increased considerably during the second five-year period. Thus, for instance, the average yield of raw cotton in Uzbekistan was 8.9 centners per ha in 1933; yet by 1939 it had increased to 17 c per ha; i.e., it had almost doubled. The yields of other technical crops which were receiving mineral fertilizers also increased considerably.

During the third five- year plan, up to the beginning of the Great Patriotic War, production and use of mineral fertilizers in the USSR continued to expand rapidly. In war time the production of mineral fertilizers was greatly impaired; their application on the fields of kolkhozes and sovkhozes was sharply curtailed. After the victorious termination of the Great Patriotic war, mineral fertilizers played a very important role in the reconstruction of agriculture, and by decision of the Party and the Government, they have been applied in recent years not only under technical crops, but also under subsistence crops - cereals, potatoes, vegetables.

The September Plenum of the Central Committee, Communist Party of the Soviet Union resolved on a further sharp expansion of production capacity and of the use of mineral fertilizers. It says in the Plenum decree - "To instruct the Ministry of the Chemical Industry and the Ministry of the Metallurgical Industry to increase from 1954-1963 the production capacity for mineral fertilizers (converted to

[1]For details concerning the works of Academician D.N. Prianishnikov see "Priroda", 1954, no.1.

conventional units) up to approximately 16.5-17.5 million tons in the year 1959, and up to 28-30 million tons in the year 1964. To bring the output of superphosphate in granular form in the year 1955 to 45 percent, and in the year 1958 to 60 percent of the total production of superphosphate. To supply agriculture, beginning with the year 1956. with ammonium nitrate in granular form only. To work out a plan for widespread utilization of Khibinsk apatites as well as local phosphorites to meet the needs of agriculture"[1].

The manufacture and application of so large a quantity of mineral fertilizers will play a particularly important role in the sharp increase in yields of cultivated plants and in the growth of agricultural production.

The principal types of mineral fertilizers manufactured by our chemical industry are nitrogen, phosphorus and potassium fertilizers.

At present, the bulk of nitrogen fertilizers is being utilized to cultivate technical crops. Their application under grain crops is limited to small amounts of nitrogen used as spring side-dressings, and the portion of vegetables and forage crops receiving nitrogen fertilizer is very small. In future the standards for the use of these fertilizers for subsistence crops will widen markedly.

The instruction of the September Plenum of the September Plenum of the Central Committee, KPSS, on supplying agriculture, beginning 1956, with ammonium nitrate - the principal nitrogen fertilizer - in granular form only, is of grat importance. Ammonium nitrate is a very effective fertilizer, but it deteriorates in storage and very often forms lumps; hence it must be ground a gain before it can be used. This great shortcoming of ammonium nitrate can be eliminated by granulation, since granular nitrate does not deteriorate.

In the future phosphorus fertilizers will also be used to a much greaterextent than at present. Furthermore, as the amount of superphosphate increases; the manufacture of phosphorite fertilizer will also increase; [Begin p.13] the wide possibilities for utilizing this good phosphorus fertilizer are not by far being fully exploited. To raise the effectiveness of this fertilizer, composting of phosphorite fertilizer with manure must be practiced more extensively. Composting increases the effectiveness of the manure as well as of the phosphorite fertilizer. Besides, phosphorite fertilizer in composts with manure produces considerable effect not only on highly and moderately acid soils, but also on mildly acid and neutral soils.

[1]Concerning measures for the future development of agriculture in the USSR. Decree of Plenum of Central Committe KPSS adopted September 7 , 1953 pursuant to report of tov. N. S. Khrushchev, Gospolitizdat, 1953, p.38.

The output of superphosphate in granular form is also highly significant. If superphosphate is introduced in soil in pulverized form, the availability of its phosphoric acid to plants decreases considerably, which is due chiefly to the formation of slightly soluble iron and aluminum phosphates. If, however, granular superphosphate is introduced in soil, fixation of phosphoric acid by ferric and aluminum oxides decreases sharply, since granular superphosphate has a much smaller area of interaction with the soil than pulverized superphosphate. Therefore the effectiveness of granular superphosphate is considerably higher in most cases than that of pulverized superphosphate, particularly when applied on red soils and podzolic soils rich in ferric and aluminum oxides. Granular superphosphate is expecially effective when it is introduced into rows together with seed.

Heretofore, it was held that our [Soviet] agriculture is considerably less in need of potassium fertilizers than of the nitrogenous and the phosphoric types. Scientific investigations and industrial experience, however, show that, as the yield increases, the need for potassium fertilizers grows. In addition, the application of potassium fertilizers is even now most important for a series of agricultural plants (legumes, plants with edible roots, potatoes).

It must also be noted that plant requirements for potassium fertilizers depend to a high degree on the properties of the soil. The application of potassium fertilizers is particularly important for light sands and sandy loam soils stretching in our Union over wide expanses. It is entirely impossible to manage a farm without the application of potassium fertilizers on peat-bog soils. Here it is necessary to apply potassium fertilizers in considerably larger doses, and every year at that. Hence, in connection with the anticipated drainage and adaptation

Illustration
Mechanized placement of mineral fertilizers.
Kolkhoz named after I.V. Stalin, Novo-Ukrain District, Kirovograd Region, Ukranian SSR
Photo by G. Verushkin

of vast areas of peat soils within the near future, agriculture's demand for potassium fertilizers will increase sharply. At present, the main potassium fertilizer is potassium chloride manufactured by our chemical industry at the base where Solikamsk potassium salts are being processed. Potassium chloride is an effective fertilizer with a high potassium content (about 55%), but it has an essential shortcoming; namely, chloride fixed with potassium has a negative effect on a number of agricultural plants including such important and widely distributed crops as potatoes, tobacco and grapes.

Therefore, our chemical industry puts out for fertilizing purposes also some potassium sulfate the amount of which will have to be increased in the future. Besides, there will be a marked expansion in the production of potassium fertilizers from salt deposits in the Western Ukraine. They offer the possibility of manufacturing potassium fertilizers in which a part of the potassium is fixed with sulfuric acid. Along with potassium, these fertilizers contain a considerable amount of magnesium one of the most important elements in the nutrition of agricultural plants. [Begin p.14]

ILLUSTRATION

Broadcasting of mineral fertilizers by airplane. Kolkhoz "Chervonyi stop", Trostianets District, Vinnets Region, Ukranian SSR.

Photo by E. Kopyt

Many crops quite frequently experience a lack of magnesium, particularly on light soils, and under conditions of liming, not only on light but also on heavier soils if the lime fertilizers used do not contain a considerable amount of this element. From the salts of the West Ukranian deposits potassium magnesium [kali-magnezia] is being produced -a splendid fertilizer containing about 26-28% potassium oxide. In the futrue, the production of this fertilizer should be expanded considerably. The unit weight of low-percentage potassium fertilizers (kainite) manufactured also by industry on the basis of West Ukrainian salts must decrease.

The assortment of mineral fertilizers must be extended chiefly on account of the output of fertilizers with a higher content of active substances, particularly on account of compound fertilizers containing two or three nutrient substances.

The use of organic fertilizers, first of all manure and peat, is of utmost importance. In the Decree of the September Plenum of the Central Committee, KPSS, it is indicated that it is necessary "to provide for a considerable increase in the accumulation and application of local fertilizers (manure, peat, liquid manure, various composts etc). In regions with peat deposits, to increase the preparation of peat for fertilizing and litter. To organize on a large scale the preparation and application of composts and organo-mineral mixtures so as to increase within the next 2-3 years the use of organic fertilizers on kolkhozes by one and a half 2 times to compared with the year 1952"[1].

Up to now, there still is the widespread opinion that the application of local fertilizers cannot be considered as a chemical means applied to agriculture; that, for example, the effect of manure or other organic fertilizers is not due to any essential chemical action upon the soil.

[1] Measures for the future development of agriculture in the USSR. Decree of Plenum of Central Committee, KPSS, adopted September 7, 1953, pursuant to report of tov, N.S. Khrushchev, p.38.

The inaccuracy of this opinion is visible from an examination of the processes caused by the introduction of manure in the soil. Not only large amounts of nitrogen, phosphorus and potassium are introduced into soil together with manure, but also a great deal of calcium, magnesium and other cations which, following the decomposition of manure in the soil, displace hydrogen-ions and enter the absorption complex. As a result, soil acidity decreases under the influence of manure, although to a lesser degree than through the introduction of normal doses of lime. Manure causes also fixation of motile soil aluminum, thus reducing the injurious action of the latter upon plants. Manure contains different microelements including boron, manganese. The positive effect of manure is in a large measure due to the fact that it adds to the soil a large quantity of useful microörganisms and energy material essential to the activity of microbes.

As manure decomposes, a large amount of carbon dioxide becomes isolated in the soil; first it saturates the soil solution; second, while separating from the soil, [Begin p.15] it increases the carbon acid content in the lower layers of the air. Saturation of the soil solution by carbon dioxide makes it a more energetic reagent which facilitats the solution of nutrient elements contained in the soil (for instance, phosphorus compounds) and their conversion into a state of greater availability to plants. An increased content of carbonic acid in the lower atmospheric strata produces a positive effect on agricultural plants. Besides, as demonstrated by investigations including those conducted with the radioactive carbon isotope (C^{14}), carbon dioxide can enter the plant not only through the leaves, but also through the roots. As a result, the increased concentration of carbon dioxide in the solution of soil helps to increase its content in the plant and to strengthen photosynthesis.

Manure produces a strong positive effect upon the yield of agricultural plants not only in the first year of its introduction in the soil, but also in subsequent years. An experiment conducted by the Institute of Socialist Agriculture of the Academy of Sciences BSSR, [White Russian SSR], at its central experimental base in "Ust'e", Orsha area, Vitebsk Region, can be cited as a brilliant example of the high effectiveness of manure on sod-podzolized loam. In this experiment, after an application of 40 tons of manure, the yield of winter wheat grain rose from 17.9 to 32.3 centners per hectare, and the hay yield of mixed grasses seeded under rye and composed of red clover and timothy increased the following year after the introduction of manure from 66.5 to 111.2 centners per hectare.

Due to inadequate storage, frequently more than half of the nitrogen content of manure and a considerable portion of its phosphorus and potassium are lost. Yet those losses could be sharply decreased by implementing certain measures that can be easily realized on consolidated kolkhozes and sovkhozes. We have in mind the construction of manure storages and liquid manure receptacles, an increase in the amount and improvement of the quality of litter, plowing under of manure in good time after it has been spread over the field. These measures will conserve a larger amount of nutritive substances for agricultural plants than our farms can obtain from industrial fertilizers.

The fertilizing action of manure depends largely on the method of its preparation. The basic one should be the currently recommended compact method for stacking manure. Stacking it solidly in manure storages as well as in stock-piles built near the farm or in the field will ensure a fertilizer of good quality, with losses of nutrients falling considerably below those in loose storage.

Our country's rich reserves of peat can be utilized widely as fertilizers. As a rule, peat manure is as good as the customary straw manure and very often exceeds it in effectiveness. Thus, for example, according to data of the Institute of Socialist agriculture of the Academy of Sciences, BSSR, one of the experiments conducted on sod-podzilized loam at the Atolino-Priluki sovkhoz, Minsk Region, produced the following potato yield: without the application of manure -- 121.0 centners per ha, after introduction of 36 tons of straw manure on 1 ha - 179.0 centners per ha, and after introducing 36 tons of peat manure on 1 ha - 186.4 centners per ha.

To utilize peat manure and other peat fertilizers to a greater extent, it is essential to adapt the application of a special factory-made peat litter to agricultural production, along with peat prepared by kolkhozes and sovkhozes themselves. In pressed form, this litter can stand long distance transportation and, consequently, it will find application also on farms which have no peat moss near their fields. Peat litter might play a particularly important role on suburban vegetable farms which usually have a poor supply of straw. Besides, it must be taken into account that each ton of factory-made peat litter will produce 6-7 tons of good manure.

Peat ought to find widespread use also in the form of composts and mixtures with various materials. According to data of White Russian scientific-research institutions, the effectiveness of a peat-manure mixture (one part of manure to one-two parts of peat) is equivalent or almost as good as that of manure. This can be judged by the results of an experiment conducted at "Ust'c". In this experiment the yield of winter wheat grain constituted: [Begin p.16] 18.1 centners per ha without introduction of organic fertilizers, 31.7 centners per ha after adding 40 tons of manure, and 30.3 centners per ha after adding 40 tons of a peat-manure mixture (one part of manure to one part of peat); the yield of hay of perennial grasses (clover + timothy) seeded under rye was 91.6, 123.9 and 117.0 centners per ha respectively.

ILLUSTRATION

Preparation of peat composts.
Unloading of liquid manure from
motorized cistern

At present peat-manure mixtures are being applied not only in the White Russian SSR, but also in various regions of the RSFSR - Moscow, Leningrad, Kirov and others. The most important peat composts are peat-liquid manure and peat-excrement composts.

Along with the intensive peat fertilizers listed above, the dried-off and wind-aired lowland peat must find application in pure form also. Lowland peat produces a smaller increase in yield than do intensive peat fertilizers, such as peat manure, peat composts or mixtures. Peat in pure form can, however, be utilized in instances when there is more peat available for fertilizing than is needed for the preparation of mixtures, composts and manures. If applied correctly and in sufficient amounts (not less than 40 tons per ha), then dried and wind-aired peat aids considerably in raising the yield of agricultural crops. Thus, for instance, in the experiment conducted by the Institute of Socialist Agriculture of the Academy of Sciences, BSSR, at "Ust'e", the yield of hay of perennial grasses (clover / timothy) increased from 24.1 centners to 93.7 centners per ha, because the soil was fertilized with 40 tons of peat.

A highly effective method of utilizing peat is to employ peat-humus pots to grow vegetable seedlings.

In addition to manure and peat, it is essential that other local fertilizers, such as excrements, city refuse, barnyard manure, pond silt be utilized more extensively. A considerable increase in productivity can be achieved if these fertilizers are applied correctly. The high effectiveness of excrement fertilizer can be estimated by data of an experiment conducted by the Institute of Socialist Agriculture of the Academy of Sciences, BSSR; the yield of forage beets on a control test plot was 181.9 per ha, but after application of 36 tons of peat-excrement compost on 1 ha, it rose to 745.6 centners per ha.

City refuse can be utilized widely as a fertilizer on suburban farms; it is best to let it first seep throught a compost pile. In addition, city refuse is used on truck-farms as a biological fuel.

In many regions conditions favor the application of green manure, primarily in the form of lupine. Lupine is particularly important in the reclamation of sandy soils. Nonetheless, it can be used as green manure also on clayey sod-podzolized soils. Thus, for instance, at "Ust'e", the yield of winter rye grain obtained on a control test plot on clayey sod-podzolized soil was 11.2 centners per ha, yet on the test plot fertilized with lupine - 21.2 c per ha.

Results of investigations conducted in recent years show the high effectiveness of green manure combined with peat. Thus, on the experimental field fertilized with green manure combined with peat (40 tons per ha at the "Ust'e" experimental base, the hay yield of perennial grasses (Clover ≠ timothy) rose from 22.0 to 78.2 centners per ha.

The principle plant cultivated for green manure is the blue angustifolium lupine. However, in various localities of our country, particularly in the West, [Begin p.17] it is expedient to sow yellow lupine. The crop of perennial lupine should also find application, particularly in the northern part of the USSR.

Special attention ought to be paid to a more extensive distribution of the crop of mildly alkaloid (forage) lupines. These lupines make splendid forage plants, while their root mass, harvest waste as well as their aftermath perform the function of green manure. The aftermath of serradella could also be used as green manure to good advantage.

In the Soviet Union, especially in the non-black soil belt, are found vast areas of land with heightened acidity detrimental to most cultivated plants. Such soils contain little organic matter or nutritive elements, possess poor physical properties, poor structure, and hence are little productive. On acid soils, various agrotechnical measures including the use of fertilizers very often not only fail to produce a full effect, but sometimes even exert negative action. To improve the agronomic properties of these soils it is necessary, first of all, to reduce their excessive acidity by liming. In liming soil in grass-field crop rotations, one must strive to reduce excessive soil acidity to a mildly acid reaction which is best for the development of perennial grasses used in grass-field crop rotations and for most other agricultural crops.

Liming exerts on soil multiple action. Its positive effect is manifest in the following: it eliminates excessive acidity and the action of motile aluminum compounds harmful to plants, which is connected with the acidity, as well as excess manganese. Liming creates favorable conditions for the activity of useful microorganisms. Under the influence of chemical, phsicochemical and biological processes which originate in the soil due to liming, there occurs an increase in the content of nitrogen, phosphorus, potassium, calcium, magnesium, and molybdenum compounds, and of other nutritive substances available to plants. The physical properties of the soil improve, particularly soil structure, as do the water, air and nutritive regimes of the soil. Together with lime the soil is fed calcium - one of the basic nutritive substances of plants, the lack of which is often felt by different crops grown on sod-podzolized soils.

Liming of acid sod-podzolized soils is a very effective method of increasing the productivity of agricultural crops. The general inference of data on field experiments conducted in the Soviet Union is that average gains in yield from soil liming fluctuate for grain crops (grain) from 2 to 6 centners per ha; for hay of perennial grasses (clover ≠ timothy) from 10 to 15 centners per ha; for fodder beets (roots) and fodder cabbage from 40 to 100 centners per ha; for table beets (roots) and table cabbage from 30 to 80 centners per ha.

Red clover and mixed perennial grasses, in the composition of which clover belongs, respond to liming particularly well. The increase in hay of mixed grasses, consisting of clover and timothy, frequently reach 30-40 centners per ha and above. Furhtermore, under the influence of liming, hay of mixed grasses experiences an increase in albumin and vitamin content, as well as in phosphorus and calcium, which is most significant for the quality of forage; clover which very often fails on unlimed soils shows increased winter hardiness.

ILLUSTRATION

Transporter broadcasts fertilizers "TUR - 7" on the field

[Begin p.18] In view of the high responsiveness of clover as well as of other perennial grasses to liming, this measure is most important factor in introducing correct crop rotations with seeding of grasses on acid soils. Soil liming is the medium for obtaining high and stable crops of perennial grasses with a powerful root system. Liming produces high increases in the yield of various other crops: plants with edible roots, cabbage, wheat, barley.

If lime is added in doses reducing soil acidity to a mildly acid reaction; i.e., in normal (full) doses, the action of liming will manifest itself for 10-15 years and longer. Thus, for the period of its effect on sod-podzolized soils with heightened acidity, each ton of lime produces a total increase in the yield of all plants grown during that period equivalent in terms of grain to 12-15 centners of the production.

Liming influences not only the magnitude of the yield but also its quality; with an adequate magnesium and boron content in the soil, the influence of liming increases the sugar content in the roots of plants-with-edible roots, of starch in potatoes, fats in seed, vitamins in different plants, and also improves the properties of seed grain and increases their productivity. In addition, the improved seed grain (yield) properties can be transmitted through heredity from generation to generation for a number of years.

The effectiveness of liming depends to a high degree on the doses of lime and methods of placement. In determining lime dosages, one should proceed from the above cited basic hypothetical principle of soil liming pursuant to which heightened soil acidity must be reduced to a mildly acid reaction. The amount of lime required for it depends on the soil properties, particularly on soil acidity and the mechanical composition of soils, as well as on their content of organic substances. If the content of organic substances in sod-podzolized soils is not over 3%, then it comes to 4-6 tons per ha for medium and heavy loams, and to 2-4 tons per ha for light loams and sandy soils. The application of such quantities of lime ensures considerable growth in the yield of most agricultural plants during one or even two rotations of a seven-ton field crop rotation.

The amounts of lime indicated above can be applied not only by one method, but by several. This constitutes another important hypothesis of modern soil liming which proves that it is possible to repeat the application of reduced doses of lime more frequently than in liming with full doses.

Soil can be limed with different types of lime rock and industrial waste and, in the first place, with materials which need not be ground or calcinated; namely, loose lime rock and lime waste of industry of which the Soviet Union has huge reserves. The basic loose lime rock constitutes lime tuffs, ground dolomite [dolomitovaia muka], lake lime, chalk-marl and marl. The main lime wastes are: ash of igneous-shales, waste of the sugar industry (defecation), waste of the lime, cement and Silicate, metallurgical industries, waste accumulated in pits at the places where lime is being mined for the needs of industry and road construction, and peat ash.

Soil can be limed with hard lime rock, with ordinary and dolomitic limestone and dolomite, as well as with solid chalk. To do this, it is necessary to organize the grinding of of those rocks and in areas rich in fuel - their calcination.

Some of the indicated materials contain magnasium along with calcium; for instance, ground dolomite, different products of aerated dolomitic limestones and dolomites, as well as ground lime [izvestkovaia muka] prepared form these rocks, slaked lime, dolomitic dust, and some marls. Lime fertilizers containing magnesium produce a larger increase in the yield of many agricultural plants (clover, alfalfa, lupine, serrella and other legumes, plants with edible roots, potatoes, onions etc.) than fertilizers with an inconsiderable admixture of magnesium. [Begin p. 19]

It is extremely important to combine the liming of soil with the application of manure and other organic as well as mineral fertilizers; the highest yield of agricultural crops can be obtained by this medium.

If soil is limed in correct crop rotations with seeding of grassed, one to begin with must strive to create conditions favorable for the growth and development of perennial grasses. This embodies the third fundamental hypothesis of modern soil liming. Proceeding from this hypothesis, it is necessary to introduce lime under a winter or spring crop serving as a cover crop for grasses, if good yields of perennial grasses are to be obtained.

Liming of sod-podzolized soils with heightened acidity is also highly significant in solving other agricultural problems - in the cultivation of sod-podzolized soils, deepening of the plowing layer, creation of a forage base, moving different plants from more southerly regions onto the non-black soil belt, creating conditions for better utilization of commercial mineral fertilizers.

The prime importance of liming was noted by comrade G. M. Malenkov in a report to the 19th conference of the Party. Posing on the problem of how to increase productivity in the non-black soil belt of the Soviet Union, he said: "To obtain high and stable yields of agricultural crops here, it is necessary, first of all, to organize large scale liming of acid soils with a simultaneous application of sufficients amount of organic and mineral fertilizers, to develop grass culture to the utmost, to improve tillage"[1]. Our country has vast areas of saline soils which in most cases contain much sodium and sometimes magnesium and other cations, yet its calcium content is small. These soils are distinguished by poor agronomic properties and they produce low yields. The properties of these soils can be radically improved by substituting sodium found in a state of absorption (or some cation) for calcium. This can be accomplished by treating the soils with gypsum. In localities with saline soils gypsum treatments are of prime importance.

Striving to fulfill the decisions of the September Plenum of the Central Committee, KPSS, on raising the agricultural level, in addition to fertilizers already adapted to agricultural production, it is necessary to utilize also fertilizers which are not as yet in use, or have been applied on a very small scale. This pertains primarily to microfertilizers containing elements required by plants in negligible quantities (microelements)[1].

Microfertilizers currently in use are the copper type applied on peat soils on which for lack of them, the grain in a series of grain crops fails to develop altogether, or develops abnormally, while many other crops produce reduced yields. The basic copper fertilizer is pyrite cinders containing, besides copper, different other elements in large amounts.

In the Soviet Union boron fertilizers are also applied, although in small quantities. These fertilizers produce an especially high effect under conditions of limed sod-podzolized soils. Boron fertilizers not only increase the yield of flax, but they also improve the quality of its fiber and raise the plant's resistance to bacteriosis. The use of

[1] G. Malenkov. Complete report on the work of the Central Committee of the VKP(b) submitted to the 19th Party conference, Gospolitizdat, 1952, pp. 54-55.

[1] Concerning this item see also J. V. Peive's article "Microelements in agriculture", "Priroda", 1953, no. 11.

boron fertilizers is also very significant in the culture of sugar beets. Liming acid sod-podzolized soils facilitates considerably the increase in sugar beet yields; yet at the same time infection of the beet roots by heart-rot and the dying-off of the point of growth are frequently observed. Boron fertilizers are a good medium in safeguarding sugar beets from these diseases. Everthing said about the sugar beet concerned the forage and table varieties, and also, although to a lesser degree, different other plants with edible roots.

Boron fertilizers have a particularly good influence upon the generative organs of plants; not only the yield of seed increases, but the properties of seed grain improve as well, and productivity rises. [Begin p.20] Hence it is essential that these fertilizers be utilized extensively in growing various plants for seed. This applies particularly to clover and to different vegetable crops, also to flax.

Manganese fertilizers are used in our country chiefly on chernozem soils in the culture of sugar beets. Nonetheless, results of investigations conducted in recent years have shown that they produce a considerable effect also in liming of sod-podzolized soils with heightened acidity. Thus arises the question concerning the application of manganese fertilizers also in the non-black soil belt of the Soviet Union under conditions of soil liming.

Our agriculture is making little use of bacterial fertilizers which represent the cultures of various bacteria facilitating the accumulation of nutrient elements in the soil or the conversion of substances contained in these elements to a state available to plants. Of bacterial fertilizers, only nitragin is being applied to a considerable extent; concomitantly with nitragin, the culture of nodular, atmospheric nitrogen-fixing bacteria is being introduced in the soil. These bacteria live on the roots of legumes forming special nodules. The action of nitragin upon agricultural plants and the conditions of application of this fertilizer in relation to the biological properties of the plants under cultivation have been studied in great detail. This circumstance permits its effective use in increasing the productivity of various legumes in relation to the specific characteristics of these plants.

Azotobacterin is used much less than nitragin; it represents the culture of the azotobacter microorganism which also fixes atmospheric nitrogen, but, contrary to nodular bacteria, lives free in the soil and not on the roots of plants.

In recent years phosphobacterin has been adapted to agriculture; it represents the culture of bacteria the activity of which is responsible for increasing in the soil the content of phosphorus compounds available to plants. The considerable increase in the yield of agricultural plants observed in many experiments with phosphobacterin justified the recommendation of this fertilizer for use in agricultural production. It must, however, be noted that conditions of effective application of azotobacterin and phosphobacterin have not as yet been sufficiently investigated.

For a number of years now, agricultural production is utilizing the bacterial preparation AMB [agar meat bouillon (?)] which very often produces a considerable effect. Nonetheless, the conditions for its use must also be defined more precisely.

At present a large part of the work with fertilizers and their use is little or not at all mechanized. This pertains particularly to manure, peat and lime fertilizer, to gypsum etc. It is sufficient to point out that hundreds of millons of tons of organic fertilizers are loaded on trucks, unloaded and spread over the field only with the aid of pitchforks. In connection with the extensive use of chemicals in agriculture to be adapted within the next few years, it is essential to increase sharply the mechanization of all processes connected with the preparation, transportation and placement of fertilizers.

Large scale application of fertilizers is a powerful factor in increasing the fertility of soil and the productivity of agricultural crops.

The natural riches of our great motherland and the huge successes of socialist industry permit the utilization of this factor to the fullest extent in obtaining an abundance of products and in unceasing the prosperity of the Soviet people.

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By: R. Adelman

Gorbachev, I. D.

Resul'taty Ispytanii novogo fosfornogo udobreniia - termofosfata1

[Results of testing Thermophosphate1 - a new phosphorus fertilizer].

Doklady Vsesouznoi Ordena Lenina Akademii Sel'skokhoziaistvennykh Nauk imeni V. I. Lenina, vol. 15, no. 10, pp.35-38
1950 20 Akl

(In Russian)

RESULTS OF TESTING THERMOPHOSPHATE -

A NEW PHOSPHORUS FERTILIZER

Submitted by Academician P. A. Baranov

It is well known that the best fertilizers for acid mineral podzolic soils and for peat-bog soils are alkaline fertilizers. These include thermophosphate[2], the new type of phosphorus fertilizer obtained by the method developed by B. N. Melent'ev (Academy of Sciences, USSR) by mixing apatite concentrate (or apatite rock), olivenite, colskite [kol'skit] and quartz in proportions determined by weight and by appropriate subsequent treatment.

This fertilizer contains up to 26% P_2O_5 (including citrate-soluble up to 24%), MgO--8-10%, CaO--18-20%, SiO_2--43-45%, Fe_2O_3--Al_2O_3--2-3%.

A study of the fertilizing action of the present thermophosphate was conducted by the author from 1946 through 1949 with different agricultural crops and on different types of soil [Begin p. 36] characteristic of the northern part of the Siberian forest zone.

The agrochemical soil characteristics of the experimental plot (arable horizon) are cited in table 1.

1 In articles and reports published earlier, the given fertilizer was known as magnesium phosphate, but in the present article it was given the name of thermophosphate which is more accurate and fits its nature.
2 The pH of its liquid extract equals 8.0.

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Tablel.

Type of soil	Salt pH	Hydrolytic acidity m.-ed. (m.ek.) per 100 gr. of soil	Sum of absorbed elements m.-ed. (m.-ek.) per 100 gr of soil	Degree of soil saturation in %	P_2O_5 mg (according to Kirsanov)	Experimental crop
Sandy.......	4.62	7.45	1.44	16.19	20.55	Potatoes (exp.1)
"	4.75	8.28	5.54	40.09	43.75	Potatoes (exp.2)
Sandy loam..	4.29	8.57	3.80	30.70	4.50	Oats & barley
Clay soil...	4.94	5.62	3.38	37.55	7.50	Oats
Lowland bogs	4.18	72.00	49.20	40.59	79.30	Potatoes
" "	4.64	65.95	33.90	34.00	23.55	Oats
Upland bogs	4.24	104.10	30.15	22.46	7.70	Oats
Lowland "	4.24	65.95	30.15	31.37	23.55	Barley
" "	4.24	60.40	45.60	43.42	23.10	Turnips
" "	4.50	63.63	65.45	50.70	91.90	Perennial grasses

On mineral podzolic soil the investigation of thermophosphate action was conducted with potatoes, and oats and barley for hay.

The experiments with potatoes were conducted for two years on a well tilled plot, on the base of organic fertilizers (peat-manure composts) in doses of 80 tons per hectare. The soil was a sandy ferrous podzol.

The experimental results are cited in table 2.

Table2.

Experimental scheme	Potatoes (1947-48) yield of tubers c/ha	Potatoes (1949) yield of tubers c/ha	Oats, yield of hay c/ha	Barley, yield of hay c/ha
NK.................	90.9	73.9	18.2	9.3
NK + P in superphosphate........	149.8	129.5	23.0	14.3
NK + P in thermophosphate.........	131.6	132.5	24.2	22.8

In the given experiment phosphorus fertilizers were applied with a disk harrow after plowing, which is less expedient than deep application.

Hence, in 1949, the experiment with potatoes was repeated. In this experiment the fertilizers were plowed under.

The results of this experiment cited in table 2 show that this time the potato yield derived with thermophosphate was as good as the yield achieved with superphosphate; this fact corroborates the above statement concerning the method of thermophosphate application.

The industrial experiments conducted on kolkhozes and sovkhozes also demonstrated the high effectiveness of thermophosphate. In these experiments, the application of thermophosphate produced a yield that was higher than the one obtained with superphosphate.

Experiments with oats were conducted for 2 years, with barley for one year. The experimental plot represented reclaimed virgin land from a spruce-birch forest. The soil of the plot was sandy loam and humic ferrous podzol. In the experiment concerned, phosphorus fertilizers were plowed under.

Table 2 shows also the advantage of thermophosphate over superphosphate when applied under the crops of oats and barley planted for hay on podzolic soils. This was particularly evident in the case of barley in which thermophosphate applied in the same dose as superphosphate increased the yield of hay by 8.5 c/ha as compared to superphosphate.

Analogous results were obtained also in vegetative experiments with oats and barley crops on podzolic (virgin as well as cultivated) sandy, sandy loam, and clay soils. Barley, for instance, gave the following yield of an airdried mass per container: on virgin and sandy soil with superphosphate - 33.5 gr, with the same dose P_2O_5 in thermophosphate - 39.5 gr, and with a one and a half doses 50.1 gr; on cultivated soil - 52.9, 70.2, 73.1 gr respectively; on virgin clay - 36.7, 42.9 and 50.1 gr.

On peat-bog soil, experiments were conducted with potatoes, with oats for hay, barley for grain, with turnips and perennial grasses.

The experiments with potatoes were conducted for 3 years, experiments with barley, turnips and perennial grasses (mixture of cereal and legume grasses of 1935 crop) for 2 years on well cultivated lowland bog. The results of these experiments are cited in table 3.

Table 3.

Experimental scheme	Lowland bog					Upland bog
	Potatoes, yield of tubers, c/ha	Barley, yield of grain, c/ha	Turnips, yield of roots, c/ha	Perennial grasses, yield of hay, c/ha	Oats, yield of hay, c/ha	Oats, yield of hay, c/ha
NK................	183.5	4.7	115.2	42.7	57.8	0
NK+P in superphosphate........	225.0	5.2	165.6	43.8	66.7	0
NK+P in thermophosphate....	261.4	7.8	208.5	46.9	66.3	25.5

Notes: 1. The experimental results in tables 2 and 3 are cited for the of years equalling the time in which the experiment was conducted.

2. Fertilizer was applied under experimental crops in the following doses; potatoes - $N_{80}K_{120}P_{80}$; oats and barley for hay - $N_6K_{60}P_{60}$; barley for grain - $N_3K_{70}P_6$; turnips - $N_{80}K_{90}P_{80}$; perennial grasses - $N_{60}K_{80}P_6$. [⊗]

3. The good yield obtained with NK in the experiments on peat-bog soil can be explained by the fact that in the years preceding the experiment, large doses of phosphorus fertilizers were applied on the plot.

Data in table 3 show that the yield of potatoes, barley (grain), turnips and perennial grasses on bog with thermophosphate is higher than the yield gained superphosphate.

In addition, it must be noted that thermophosphate, concomitantly with increasing the productivity of perennial grasses, exerted an influence also on the composition of the grass mixture; on test plots where this fertilizer was applied, the amount of grasses valuable as forage crops had increased (timothy, foxtail).

[⊗Trans. note: fertilizer dosages in note 2 are practically illegible in original text.]

Industrial experiments in which thermophosphate was applied under perennial grasses on lowland bog produced the same results.

The data show that with the crop of oats planted hay on lowland bog, thermophosphate equals superphosphate in effectiveness. Analogous results were obtained also in vegetative experiments with virgin peat of lowland bog.

The situation is entirely different on upland bog where we were unable to obtain a yield of oats with a selection of the usual mineral fertilizers containing superphosphate. Sprouts advanced in height only 5-6 cm, had a stunted appearance and a yellow color, and they remained like that for the rest of the summer. In contrast to this, the yield of hay from oats obtained with thermophosphate was 25.5 centners per ha.

Similar results were obtained in vegetative experiments with peat of upland bog in which, upon application of superphosphate, oats perished completely after reaching barely 5-6 cm in height; yet with the use of thermophosphate it showed powerful development, had a normal dark-green coloring, reached a height of 70 cm and produced the high yield of 61.5 gr of air-dried mass per container. [Begin p. 38]

Besides the experiments conducted to investigate the effect of thermophosphate upon the productivity of agricultural crops in the year it is applied, a study was also made of the action it exerted in subsequent years, and of the influence of thermophosphate of various grists.

A study of the aftereffect of thermophosphate on peat-bog soils was conducted with perennial grasses. The experiments demonstrated that the aftereffect of thermophosphate on these soils is more pronounced than its direct action. For example, the yield of hay of perennial grasses obtained a year after the application of superphosphate amounted to 44.2 centners per ha; yet after thermophosphate it was 51.5 c/ha.

Studies of the aftereffect of thermophosphate on mineral soils are still incomplete and more work must be done in this direction.

A study of the effectiveness of thermophosphate of different grists was conducted in vegetative experiments. They showed that to obtain good results, the grist of thermophosphate must compare to Thomas slag; i.e., it must not exceed 80 mesh in coarseness; the use of coarse grist thermophosphate reduces strongly its effectiveness in the year it is applied. This is particularly apparent on mineral soils, but less pronounced on peat. For example, on sandy ferrous podzol, in the year of application, the yield of the air-dried mass obtained from one container was: oats, after coarse thermophosphate (30 mesh) - 17.34 gr, after fine (80 mesh) - 31.29 gr; barley - 11.52 gr and 41.56 gr respectively.

CONCLUSIONS

1. As a phosphorus fertilizer, thermophosphate is fully adaptable to mineral podzolic and peat-bog soils of the North. With respect to its effectiveness on mineral soils, it equals superphosphate, and on peat soils it excells it.

2. To obtain greater effectiveness of thermophosphate on mineral soils, it must be plowed under. This method of application increases its availability to plants.

3. The grist is of decisive importance in the adaptation of thermophosphate, it must not exceed 80 mesh.

4. The application of thermophosphate produces satisfactory yields on acid upland bogs without the use of neutralizers (lime, nepheline etc).

5. Thermophosphate is a very valuable fertilizer for the northern part of the podzolic zone and for peat-bog soils; it excels superphosphate in effectiveness.

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Baranov, P. A. and Koren'kov, D. A.

O novom vide slozhnykh kontsentrirovannykh beschlornykh udobrenii

[New type of compound concentrated non-chlorous fertilizers].

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Aug. 1954 20 Z44

(In Russian]

NEW TYPE OF COMPOUND CONCENTRATED NON-CHLOROUS FERTILIZERS

The Institute of General Inorganic Chemistry of the Academy of Sciences, USSR (A.Ia. Zvorykin and F.M. Perel'man), has developed a method for obtaining a compound concentrated non-chlorous fertilizer. It is composed of potassium and ammonium phosphates which crystallize themselves in the process of their production in so close a contact, as if each of the salts had been "dissolved" into the other. Because of this, the authors gave the fertilizer the additional name of "solid solution". This fertilizer contains about 5% of nitrogen, about 50% of phosphorus, and about 22-23% of potassium.

In recommending this fertilizer for production, the authors point at a series of its advantages over ordinary fertilizers.

In the opinion of the authors, this fertilizer is more effective than a corresponding mixture of simple fertilizers and, in addition, it eliminates the need of mixing simple fertilizers. The other advantage of this fertilizer, the authors point out, lies in its high content of nutrient substances and in the absence of ballast matter, particularly chlorine.

Regardless of the fact that the matter had not been sufficiently investgated, the above fertilizer was widely advertised by the authors. Particularly A.Ia. Zvorykin, in his article "New Type of Mineral Concentrated Fertilizers", published in No. 273 (6379) of the newspaper "Socialist Agriculture [Sotsialisticheskoe zemledelie]" of November 19, 1952, cited a line of figures obtained from results of experiments conducted with different crops which indicated the advantages of the above fertilizer over ordinary types.

Upon the suggestion of the Ministry of Agriculture, USSR, the All-Union Scientific Research Institute for Fertilizers, Agrotechnics

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and Agro-Soil Science, and a number of other scientific research institutions conducted in 1953 field and vegetative experiments to test the proposed fertilizer (hinceforth to be referred to as potassium-ammonium-phosphate) on a series of agricultural crops under different soil and climatic conditions.

During the testing this fertilizer was compared with concentrated fertilizers containing no chlorine (ammonium nitrate, double superphosphate or ammophos, potassium sulfate).

The varied content of nitrogen, phosphorus and potassium within potassium-ammonium-phosphate was taken into consideration during the experiments. H ence this fertilizer was tested with and without additive of other concentrated fertilizers, bringing the nitrogen, phosphorus and potassium doses up to the proportions adopted in practice.

To bring out the advantages of potassium-ammonium-phosphate more fully, the experiments were conducted under conditions favorable to the action of this fertilizer: the choice of crops was limited to those sensitive to chlorine and to saline concentrations in general, and of soils as light as possible. Along with broadcast placement, [Begin p.61] the fertilizer was tested also under conditions of localized application at planting time.

Vegetative experiments. The experiments conducted by VIUAA All-Union Institute of Fertilizers, Soil Science, and Agricultural Engineering] (Candidate for Agricultural Sciences, A.M. Shchepetil'nikova) with flax on podzolized sandy loam and clay soil have shown (table 1) that the compound fertilizer potassium-ammonium-phosphate, applied without an additive of nitrogen fertilizer, (var. 2) produces the same effect as an equivalent amount of simple concentrated fertilizers (var. 3).

T a b l e 1.

No. in conc. order	Expermental variant	Yield of flax (in gr per container) on: Sandy loam		Clay soil	
		Fiber [solomka]	Seed	Fiber	Seed
1	No fertilizer...............	4.21	0.72	8.69	1.72
2	Potassium-ammonium-phosphate (in dose of 0.2 gr P_2O_5 per container).................	5.48	0.96	9.57	1.77
3	Binary superphosphate (0.2 gr P_2O_5 per container) ≁ ammonium nitrate and potassium sulfate (in dose of var.2)	5.73	1.15	9.95	1.85
4	Ammonium nitrate ≁ potassium sulfate (base)..............	11.36	3.11	13.90	4.37
5	Base ≁ potassium-ammonium-phosphate..................	14.18	3.67	18.69	4.78
6	Base ≁ binary superphosphate	13.96	3.69	17.90	4.92
7	Base ≁ simple superphosphate	11.62	3.23	15.37	4.55
8	Ammonium nitrate, simple superphosphate, potassium chloride	10.88	3.29	--	--

Only by adding a sufficient amount of nitrogen fertilizer and potassium sulfate (var.5) a marked increase in fiber yield (by 2-2.5 times) as well as in seed yield (by 3-3.5 times) was obtained.

A 2-3 time increase in yield was obtained from potassium-ammonium-phosphate and from the comparable potassium phosphate [fosforno-kaliinogo] fertilizer on a nitrogen base on light sandy loam as well as on heavy clay soil (var. 1 and 2, 4 and 5). However, the simple concentrated fertilizers - ammonium nitrate, binary superphosphate and potassium sulphate - produce under analogous conditions practically the same effect as the fertilizer under investigation (var.6).

On a base of an adequate dosage of nitrogen and potassium fertilizer (in the form of potassium sulfate), the fertilizer under investigation produces a large increase in yield as compared to a selection of simple fertilizers only if binary superphosphate is substituted with an ordinary pulverized type (var.7), and potassium sulphate is substituted with a chlorous type (var.8).

The effectiveness of potassium-ammonium-phosphate in localized application at planting time was studied in another experiment with flax on sandy soil. The results are cited in table 2.

Data in table 2 show that neither the absolute yield nor the increase produced by the fertilizer was large (var.2), when the application of potassium-ammonium-phosphate was localized (under the seed) (var.2). An equivalent dose of phosphorus and potassium (in the form of binary superphosphate and potassium sulfate) produces the same effect as the fertilizer under investigation (var. 4).

Yet, by applying an adequate dose of nitrogen fertilizer (in the form of a side-dressing at the bottom of the container), the effect derived from applying the fertilizer under investigation under the seed increased by more thah twice (var. 6).

Table 2.

No. in cons. order	Experimental variant	Yield of flax (in gr per container)	
		Fiber	Seed
1	No fertilizer..................	4.21	0.72
2	Potassium-ammonium-phosphate (0.1 gr P_2O_5)	5.1	0.83
3	Binary superphosphate (0.1 gr P_2O_5)	4.23	0.69
4	Same ≠ K_2SO_4 (equivalent to var.2)	5.04	0.93
5	Base (ammonium nitrate ≠ potassium sulfate) (N--0.25 gr, K--0.5 gr)	7.84	2.70
6	Base ≠ potassium-ammonium-phosphate (0.1 gr P_2O_5)....................	9.95	4.07
7	Base ≠ binary superphosphate (0.1 gr P_2O_5)...........................	9.54	3.84

N o t e: phosphates were introduced 2 cm below seed (in rows).

Under these conditions, the effect of simple concentrated fertilizers also rose sharply, and a certain decrease of it, as compared with the fertilizer under investigation, can obviously be explained by the fact that no potassium sulfate was introduced in the "rows" in these experimental variants (var.7).

The experiment with flax was conducted also by the All-Union Scientific Research Institute for Agricultural Microbiology on sod podzolized moderately clayey soils. The fertilizers were introduced at the rate of 0.1 gr K_2O per kg of soil. The amount of the other fertilizers was calculated in conformity with this dose. Data of yield are presented in table.3.

Table 3.

No. in cons. order	Experimental variant	Yield of flax (in gr per container)	
		Fiber	Seed
1	Control (no fertilizer)...............	21.9	6.8
2	Potassium-ammonium-phosphate..........	31.5	6.8
3.	Ammonium nitrate, binary superphosphate, potassium sulfate (in dose of var.2)...	32.6	8.44
4	Potassium-ammonium-phosphate with additive of ammonium nitrate and potassium sulfate as a side-dressing............	49.8	14.3
5	Ammonium nitrate, binary superphosphate and potassium sulfate (doses and placement methods analogous with var. 4)....	53.6	15.4
6	Ammonium nitrate, simple superphosphate and potassium sulfate (doses and placement methods analogous with var.4).....	53.9	15.5
7	Ammonium nitrate, simple superphosphate, potassium chloride (doses and placement methods analogous with var.4)..........	52.9	17.2

The data cited confirm that potassium-ammonium-phosphate (var.2) and simple concentrated fertilizers (var. 3) added to a dose of potassium-ammonium-phosphate produced poor results, while an additive of nitrogen and potassium fertilizers mixed with the fertilizer under investigation (var.4) contributed toward a considerable increase in the yield of the fiber and the seed of flax. At the same time a mixture of ordinary fertilizers, even in the form of simple superphosphate and potassium chloride, (var. 6,7) showed better action than the fertilizer in question (with an additive of nitrogen and potassium up to a normal ratio).

Experiment with maize. A vegetative experiment was conducted by the Soil Institute of the Academy of Sciences USSR (D.M. Kheifets-Shtrausberg) on cis-Caucasian chernozem soil to study the influence of potassium-ammonium-phosphate upon the development of the vegetative mass of maize. Data on this experiment are given in table 4.

Table 4.

No. in cons. order	Experimental scheme	Weight of dry plants (in gr per container	
		for 30 days of vegetation	for 51 days of vegetation
1	No fertilizer..................	2.17	6.2
2	Potassium-ammonium-phosphate (at rate of 0.5 gr P_2O_5 per container)	3.67	10.32
3	NH_4NO_3, KCl, $Ca(H_2PO_4)_2 \cdot H_2O$ (in dose of var. 2)................	4.00	10.60
4	Potassium-ammonium-phosphate (in dose of var. 2) + NH_4NO_3 (up to 1 gr N) KCl (up to 1 gr K_2O per container)......................	6.12	31.75
5	NH_4NO_3, KCl, $Ca(H_2PO_4)_2 \cdot H_2O$ (in dose of var. 4)................	7.40	33.50

Table 4 shows that potassium-ammonium-phosphate (var.2) and an equivalent quantity of simple fertilizers (var.3) produce almost the same action exerting a mild influence upon the development of the vegetative mass of maize. By supplementing potassium-ammonium-phosphate with potassium nitrogenous fertilizers up to a normal ratio, the development of maize was considerably improved (var. 4). A mixture of simple fertilizers, however, produced a somewhat better effect than an equivalent amount of the fertilizer under investigation (var.5).

Field experiments. To test potassium-ammonium-phosphate, a series of experiments was conducted with potatoes on the podzolic soils of TSOS [Central Insurance Department of the People's Commissariat for Rail Transport (?)] VIUAA, the Novozybkovsk Experimental Station of VIUAA, at the Institute of Potato Economy, and at the

Institute of Grain Economy of the Non-Black Soil Belt. The results of these experiments are cited in table 5.

Table 5 shows that the increase in the yield of tubers and starch derived from the application of potassium-ammonium-phosphate is insignificant in localized (var.6) as well as in basic application (var.2). High yields of potato tubers and starch were obtained on all types of podzolic soils, including light sands and sandy loams, when potassium-ammonium-phosphate was supplemented with an adequate amount of nitrogen and potassium fertilizer (var.4). In addition, simple concentrated fertilizers were in every case as good as potassium-ammonium-phosphate, and in a number of cases their action was better.

Concurrently with the above, the experiments of the Institute of Grain Economy of the Non-Black Soil Belt, conducted on heavy clay soil and sandy loam (table 6) at the "Put' Oktiabria" kolkhoz, Kuntsev District, Moskow Region, demonstrated that the effect of potassium-ammonium-phosphate (var.2) upon the yield of potato tubers was inferior to that of an equivalent amount of ammonium nitrate, simple superphosphate, and potassium chloride (var. 3).

Only by supplementing the fertilizer being tested ammonium nitrate and potassium chloride (var.4), the yield of potato tubers was considerably increased, particularly on light soil. At the same time, simple fertilizers in normal proportions (var.5) produced better action on light sandy soil than on heavy clay, as compared with the potassium-ammonium-phosphate variant plus an additive of potassium nitrate fertilizers (var.4). [Begin p. 65]

Table 5.

No. in cons. order	Experimental variant	TSOS VIUAA		Novozybkovsk Experimental Station				Institute of Potato Economy				Institut of Grain Economy, Non-Blac Soil Bel
				Sandy soil				Midly podzolized soil				
		Heavy clay moderately podzolized soil		No manure		With manure		No manure		With manure		Heavy Clay moderately podzoliz soil
				Yield (in centners per ha)								
		Tubers	Starch	Tubers	Starch	Tubers	Starch	Tubers	Starch	Tubers	Starch	Tubers
1	No fertilizer........	247.6	40.1	154.8	20.2	212.2	26.9	217.8	38.1	275.0	43.7	274.9
2	Potassium-ammonium-phosphate	260.7	42.1	169.8	22.6	228.9	33.9	249.5	43.2	286.4	45.5	285.5
3	Simple concentrated fertilizers (in dose of var.2)...........	264.7	43.5	164.4	22.7	220.7	29.3	257.9	45.9	299.6	48.2	286.5
4	Potassium-ammonium-phosphate with additive of potassium nitrate fertilizer..	322.0	51.8	231.1	31.0	253.0	29.3	263.8	45.6	279.3	43.0	292.9
5	Simple concentrated fertilizers (in dose var.4)..............	318.1	53.0	249.6	33.8	260.0	32.9	291.9	50.5	281.1	43.9	293.1
6	Potassium-ammonium-phosphate under tuber	250.4	40.2	157.8	23.1	199.6	24.1	229.3	40.1	287.6	46.9	281.3
7	Simple fertilizers (in dose var.6) under tuber	251.8	41.9	185.2	25.8	212.6	28.0	226.4	39.9	298.1	50.4	289.5

Note. Second and third experimental variants had the following doses of fertilizers: N--4.8, P_2O_5--50, K_2O--23.5, fourth and fifth variants had N--60, P_2O_5--50, K_2O--60, sixth and seventh had N--3.3, P_2O_5--33.3, K_2O--14 kg per ha.

In the first three experiments potassium-ammonium-phosphate was compared with simple concentrated fertilizers: ammonium nitrate, double superphosphate and potassium sulfate, and in the experiment of the Institute of Grain Econom of the Non-Black Soil Belt, with ammonium nitrate, simple superphosphate and potassium chloride.

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Table 6.

No. in cons. order	Experimental variant	Potato yield (in cent. per ha) on: Heavy clay	Light sandy soil
1.	No fertilizer....................	109.5	60.0
2	Potassium-ammonium-phosphate 0.66 c/ha............................	170.2	110.0
3	NPK (in dose of var. 2)..........	192.0	130.0
4	Potassium-ammonium-phosphate 0.66 c/ha + NK (N--33, K_2O--33 kg/ha..	223.5	188.0
5	NPK (in dose of var.4)...........	207.7	192.0
6	Potassium-ammonium-phosphate 0.66 c/ha + N 29.7 kg/ha...............	210.0	152.0

An additive merely of a nitrogenous fertilizer increased sharply the yield of potato tubers (var.6) ensuring an additional increase in yield up to 40 c per ha.

Experiment with tobacco. Tests of potassium-ammonium-phosphate on tobacco were carried out at the experimental stations of the All-Union Scientific Research Institute for Tobacco and Makhorka. These investigations also confirmed that potassium-ammonium-phosphate fails to produce significant increases in tobacco yield without a supplementary application of potassium nitrate fertilizers; yet an additive of nitrogen and potassium to the fertilizer up to a normal ratio of the substances increased the yield and the output of high-grade varienties of tobacco. At the same time, the action of an equivalent amount of simple concentrated fertilizers was in most cases approximately the same, and in individual cases better. At the Crimean Experimental Station, in 1952, the application of ammonium nitrate (N_{30}), superphosphate (P_2O_5—100) and potassium sulfate (K_2O—100) produced a total tobacco yield of 14.1 c per ha, with the yield of its high-grade varienties being 5.5 c per ha; yet with potassium-ammonium-phosphate (P_2O_5—100) the total yield of tobacco was 11.4 c per ha, and the yield of superior varieties 5.1 c per ha. By supplementing potassium-ammonium-phosphate with a potassium nitrate fertilizer, the total yield of tobacco came to 13.3 centners including the yield of superior varieties of 5.6 c per ha. At the same station, in 1953, the tobacco harvest in the N_{30} P_{100} K_{100} variant was 10.1 centners per ha, with the yield of superior varieties being 5.7 c per ha, but in the potassium-ammonium-phosphate variants supplemented with ammonium nitrate and potassium sulfate up to the proportions indicated in the above variant, the tobacco yield came to 10.8 c per ha, and the yield of high-grade tobacco varieties to 5.6 c per ha.

At the Kotaisk Experimental Station, the following tobacco yields were obtained in 1953 (table 7).

Table 7.

No. in Cons. Order	Experimental variant	Total yield	Including yield of superior varieties as of 3rd breaking
		in cent. per ha	
1	No fertilizer..................	22.86	7.0
2	Potassium-ammonium-phosphate $N_{9,13}P_{90}K_{40,21}$ kg/ha..............	25.75	8.1
3	Ammonium nitrate, superphosphate, potassium sulfate (in dose of var 2)............................	25.63	11.1
4	Potassium-ammonium-phosphate + KNO_3 + NH_4NO_3 ($N_{45}P_{90}K_{100}$)......	28.30	7.7
5	Ammonium nitrate, superphosphate, potassium sulfate (in dose of var 4)............................	24.95	11.3

[Begin p.66] Table 7 shows that potassium-ammonium-phosphate (var.2) and an equivalent amount of single concentrated fertilizers (var.3) exerted similar action upon the total yield of tobacco. But the yield of high-grade varieties fertilized with simple concentrated fertilizers was by 3 c per ha higher than in the case of potassium-ammonium-phosphate. By supplementing it with ammonium nitrate and potassium nitrate (var.4), the total tobacco yield was 3.35 c per ha more than with simple concentrated fertilizers used in the same proportions (var.5). The yield of high-grade tobacco varieties, however, in this experimental variant with simple concentrated fertilizers was also higher by 3-6 centners than with potassium-ammonium-phosphate combined with potassium nitrate fertilizers.

Experiments of the same stations have demonstrated that the action of a mixture of simple fertilizers is more effective than that of potassium-ammonium-phosphate, if its potassium sulfate is substituted by potassium magnesium.

In addition, we shall cite the results of testing potassium-ammonium-phosphate on sunflowers and castor plants obtained in the 1953 experiments of the All-Union Scientific Research Institute for Oil Crops (table 8).

Table 8.

No. in cons. order	Experimental variant	Method of placement	Sunflower in c/ha yield	Sunflower in c/ha increase	Castor plant in c/ha yield	Castor plant in c/ha increase
1	No fertilizer........	--	26.6	--	9.9	--
2	Potassium-ammonium-phosphate $N_{0,63}P_{6,25}K_{2,75}$ kg/ha	on one side of hill	28.2	1.6	10.8	0.9
3	Organo-mineral granules NPK (in dose of var.2)	same	27.9	1.3	10.9	1.0
4	Granular factory superphosphate $P_{6,25}$ kg/ha	"	28.6	2.0	11.1	1.2
5	Potassium-ammonium-phosphate (in dose of var.2)	in hill	26.9	0.3	11.0	1.1

These data show that potassium-ammonium-phosphate (var.2) is equivalent in effectiveness to organo-mineral granules applied in the same dose (var.3), and is somewhat less effective than granular superphosphate applied in doses identical with the second and thirds variants.

Thus, the results of field and vegetative experiments indicate that potassium-ammonium-phosphate has no advantage over an appropriate selection of plain concentrated fertilizers the action of which, in a number of cases, proved to be better.

The advantage of potassium-ammonium-phosphate simmers down to nothing if the chlorous potassic salts [khloristykh kaliinykh solei] are substituted with potassium sulfate or even with the cheaper potassium magnesium. This substitution incorporates in the fertilizer not only potassium, but also other valuable nutritive elements, such as sulfur and magnesium.

The experiments have also shown that a simultaneous combination of nitrogen, phosphorus and potassium in one crystal of a compound fertilizer is not a necessity.

The difference in the motility of the ions NH_4, K, PO_4 in the soil, the series of conversions and variations which fertilizers undergo in the soil under the influence of physico-chemical and biological processes--all these phenomena and facts practically void the importance that once was attached to the close union of nutritive elements within one crystal. They remain in such a state only until they are placed in the soil, and their joint locale (focus) in the soil is very conditional for potassium and particularly for nitrogen which are distinguished by great motility in the soil as compared to phosphorus. Furthermore, the simultaneous introduction of nitrogen, phosphorus and potassium fertilizers into the soil is not prompted by therequirements of plants. As the plant develops, its requirement for nitrogen, phosphorus and potassium varies. In this connection, already D. N. Prianishnikov pointed out that the need for fertilizers depends not only on the species of the plant, but also on the properties of the soil. Potatoes on light soils, for instance, may require most of all potassium, yet on chernozem soils, phosphorus; in addition, potatoes on the same soil, thriving on manure, will sooner require a supplement of phosphorus and nitrogen than of potassium, in contrast to potatoes not fertilized with manure. The degree of clover and alfalfa participation in crop rotations also leaves its mark. Hence the simultaneous introduction of nitrogen, phosphorus and potassium fertilizers into the soil is not an absolute precondition. Besides, the results of the investigation have shown that potassium-ammonium-phosphate, thanks to the disproportion in the content of its nutritive substances, produced a high effect only when it was mixed with simple mineral fertilizers, bringing its nitrogen, phosphorus and potassium content into more effective proportions. As a result, the authors' argument that the application of the compound fertilizer proposed by them will relieve agricultural production of the task of mixing fertilizers lacks foundation.

It follows from the above statement that, in view of the absence of any advantages of potassium-ammonium-phosphate over simple concentrated fertilizers, the question of expediency of its production cannot be settled by agronomic evaluation, but solely by the technical and economic factors of its production.

Trans. A. 540
Abstract and trans.
of Conclusions
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Diagnostika morozoustoichivosti
rastenii po glubine pokoia ikh
tkanei i kletok

[Diagnosis of frost-resistance in
plants by the depth of dormancy of
their tissues and cells.]

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(Instruction in methods).

(In Russian)

DIAGNOSIS OF FROST-RESISTANCE IN PLANTS BY THE

DEPTH OF DORMANCY OF THEIR TISSUES AND CELLS.

Chapter I contains the following list of indicators of the depth of dormancy and frost-resistance in plants:

1. Conversion dynamics of reserve substances;

2. Process of the separation of protoplasm;

3. Character of plasmolysis in a saccharose solution;

4. Time of advance of cap plasmolysis;

5. Resistance of lipoids to temperature influences (in plants in whose tissues lipoids develop).

In most grass crops starch converts into sugar, in woody species into fats and lipoids. Observations of conversions are conducted with the aid of microreactions.

Plasmodesma are observed in a plant while it is in a state of vegetation. It connects adjacent plant cells, but separates itself from the cell walls as the plant enters a state of dormancy.

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If the process of protoplasm separation is not discovered directly microscopically, then the state of the cell (dormancy) can be determined by the shape of plasmolysis in a molar solution of saccharose.

The time of approach of cap plasmolysis indicates the degree of swelling of protoplasm colloids; this circumstance is one of the best indicators of the depth of dormancy.

Frost-resistant varieties of woody species are characterized by a deeper conversion of substances than varieties of poor resistance. Conversion of substances in frost-resistant plants goes far enough to form fats and lipoids; in poorly frost-resistant varieties it ends with fat-like substances or sugar. In the first, decomposition of lipoids occurs at a temperature of 70°C, in the second at 40-50°C - a factor of utmost importance in the survival of a plant.

Chapter II deals with the comparative evaluation of diagnostic methods; chapter II, with evaluation of the degree of frost-resistance in fruit crops obtained on the basis of microchemical reactions, and chapter IV, with the depth of dormancy and frost-resistance in cereals and other grass crops.

CONCLUSIONS

In summing up the above account, we are able to submit the following diagnostic scheme for frost-resistant plants.

1. Observation of dynamics of the conversion of reserve substances (the disappearance of starch and accumulation of sugar in grass crops, and fats in tree species characterize the state of dormancy).

2. Microscopic detection of the separation process of protoplasm (in a state of dormancy protoplasm separates to some degree from the cell walls) and the color of plasmodesma (the absence of plasmodesma characterizes the state of dormancy of woody and grass crops).

3. Investigation of the character of plasmolysis in a molar solution of saccharose (bulging plasmolysis - state of dormancy or emergence from it).

4. Investigation of the rate of approach of cap plasmolysis in thiocyanate potassium (the slower the approach of cap plasmolysis, the less bulging is protoplasm, the more sound the state of dormancy). The given property is particularly pronounced in tree species.

5. Investigation of the magnitude and stability of lipoidic layers (the greater the depth of dormancy, the sharper is the reaction to lipoids in tree species, and the temperature causing the destruction of lipoids must be the higher).

The above described methods determining the depth of dormancy and its relation to frost-resistance are fully within the reach of any laboratory.